INTEGRATED EDITION OF THE PETROLEUM ENGINEER

# PETROLEUM Engineer for MANAGEMENT

**FEBRUARY 1961**
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ONE DOLLAR PER COPY

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# Abrasijet...
## a profitable way to complete a well

This cross-section illustration, as visualized by an engineer, shows a formation being notched with Abrasijet* — the Dowell-developed abrasive jetting service. The drawing was based on tests in which formation samples were notched with Abrasijet.

Notice the large surface area exposed by the notch. Notching with Abrasijet is an important starting point for recently-introduced frac design techniques. Abrasijet is also used for difficult perforating, vertical slotting of casing and cleaning open holes.

Results from hundreds of wells notched with Abrasijet and fractured by Dowell have been excellent, compared with similar wells fractured after perforating with explosives. Injection pressures required for fracturing have been lowered. Production increases have been outstanding. Gas/oil or water/oil ratios were improved. Occasionally, results from Abrasijet alone have been so good that fracturing was not required.

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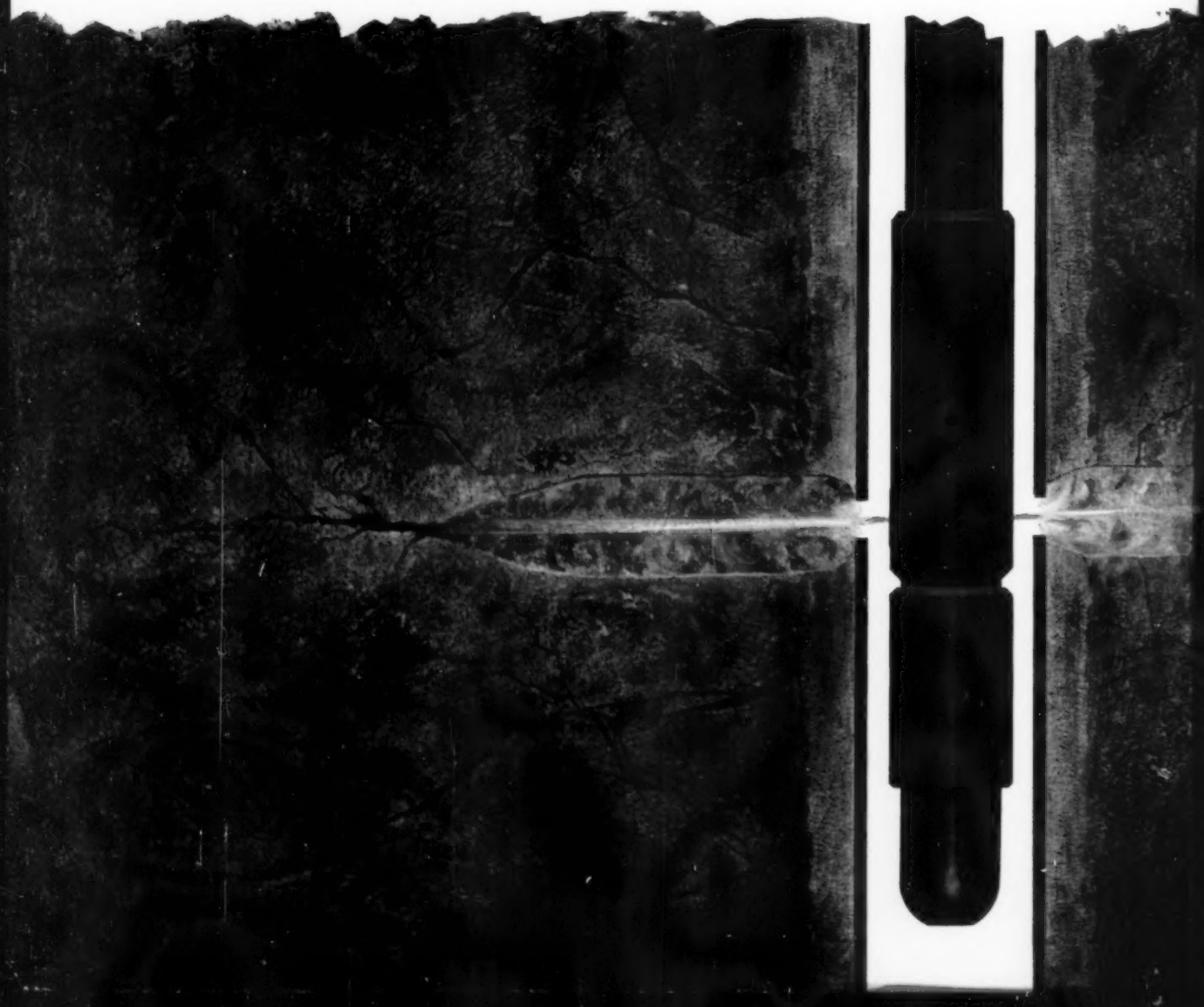

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# highlights *and footnotes of the news*

Natural Gas stored underground was made subject to a property tax by a Michigan county. Industry sources say it's the first time to their knowledge that such a levy has been imposed. Natural gas often is subjected to a severance or similar tax at the point of production.

Trinidad has agreed to exploration on 2,000,000 acres off east and southeast coast of their island, however. Pan American Petroleum Company will serve as operator, with Sun Oil Company and Pure Oil Company as partners.

1960 was one of the best years in the more than 30-year history of Houdry Process Corp. A 50-cent extra dividend in addition to the regular 50-cent annual dividend was declared in December. Consolidated earnings were estimated at $2.90 per share, vs $2.45 for the previous year. T. A. Burtis, president, says the prognosis for 1961 is "very encouraging."

Union members will get an increase despite the Union's rejection of the wage boost. Standard of California is paying Union members 5% more at its refineries after offer was rejected. The Union wanted a flat 14¢-an-hour increase for all workers which tends to level wage differentials, giving lowest paid the highest proportionate raise.

If the Tennessee-Pemex proposal to take gas into southern California falls through, another company already has its foot in the door. International Gas Company, a California-based firm says it would like to build a 30-in., $207,000,000 pipeline from the Reynosa fields in Mexico to the southern California area. Southern California Edison is reported to be the possible customer, the same as in the Tennessee-Pemex plan.

Organization of Petroleum Exporting Countries (OPEC) met in Caracas in January to discuss prices. Saudi Arabia, Iraq, Iran, Kuwait and Venezuela seek some way to have a voice in crude oil prices. Middle East producers lowered posted prices slightly last year. Although lower postings were simply a recognition that prices had dropped in actual trade, government of producing countries were displeased.

By decree of a Los Angeles U. S. District Court judge, Phillips was ordered not to acquire more Union Oil of California common stock, not to vote the 1,260,000 shares it owns and not to try to get a Phillips representative on the Union board. The Justice Department brought suit in December. The injunction will presumably last until the case is tried.

No great drilling gain this year is prediction based on U.S. Bureau of Mines estimate that crude oil production will be up 2.7%; domestic demand up 1.7%.

Delays have been shortened in handling cases, says FPC's annual report. As one example: "By quickly disposing of the first-phase issues (in an interim order) the financial burden on pipelines and distribution companies and on the ultimate consumer is eased by reducing the periods during which unjustified rate increases are in effect, subject to refund."

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# Get Your Crystal Ball Bearings

This is the time of year when the trade press, through its capable corps of analysts and writers, attempts to foretell the future — the year ahead.

Much criticism has been directed at this group during the past year or two for what is referred to as overoptimism. Certainly, some of this criticism is justified, but on the whole this group has, over the years, done an admirable job of sifting the figures necessary to come up with anything resembling a factual analysis. With so many variables involved, it follows that any prognostication can never be 100% accurate unless the person behind the pencil happens to be real lucky. Here at PE our editors try to be realists, whether evaluating an engineering article or budget figures by the oil companies pertaining to future expenditures.

Our January issue Outlook article points out that the U. S. oil industry is budgeted to spend in 1961

- $8 billion here and abroad for facilities and oil and gas reserves
- 6.6% more than the 1960 outlays
- a sum second only to 1957 capital expenditures.

This estimate, made by Ernestine Adams, Petroleum Engineer management editor, is based on confidential information supplied by 28 companies, which together will spend approximately one-half of the industry's total capital outlay this year. Miss Adams divides the $8 billion into

- $5.8 for U. S., and
- $2.2 for foreign operations.

Combined budgets are set roughly in this proportion:

- For oil and gas – 56%,
- For manufacturing – 21%,
- For transportation (not gas transmission) – 9%,
- For marketing – 12%,
- For others – 2%.

Drawing from our own analysis, plus other forecasts by leading industry authorities of U. S. oil companies, the estimated U. S. domestic oil demand will rise 2%, which compares to the 2.1% increase of 1960 over 1959. (Remember actual volume increase will be more than 1960.) U. S. crude oil production will go up by 3%. This estimate is based on the supposition that imports will be substantially unchanged from the 1960 volume. (Oil executives' forecasts ranged from 2½% to 4% increase.) Refinery runs will be up 2%; free world demand up 7.5%.

The above figures are not what we had been accustomed to expect in early post-World War II years, but they do reflect stabilization and a more normal growth pattern. The increased budgets by the oil companies will in time reach equipment manufacturers and supply and service companies, further strengthening the entire industry.

How do we use what we've learned the past few years?

It's not enough to say that recent industry history has been useful in experience, for experience has little value if it cannot be used to better a profit margin.

We have learned to "cut out the fat," but our real test as managers will be to keep out the fat when industry conditions improve, as they inevitably will. We must remember the tragedy of processing more oil than we can market; and we must remain cognizant of the importance of research for development of new products and new techniques.

In short, the lean days of the late Fifties will have value only if we can adapt — and improve — what we were forced to learn during those meager times. Put another way — 20/20 hindsight counts for little. How well will we use what we see coming up?

Joe B. Hoode

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Memo to Management:

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***Course of Oil***

# danger: dubious guideposts

MOST OF US don't remember the early days of oil operations when equipment often didn't fit and much of it had to be made on the spot. The greatest contribution American Petroleum Institute made — and still makes — to the industry is its meticulous standards that carry a stamp of quality over all the world.

Have you ever thought how lost you'd be in this world of ours without standards? These precise measurements give us freedom of operation that was undreamed of until modern times. In a Saturday Evening Post article, the head of the National Bureau of Standards said science was outstripping our present standards and that we'd have to move ahead in measurement so our advance scientifically would not slow down.

In our industry, we've progressed quickly and surely in technological measurements but now we're stumbling on more intangible and controversial standards.

One of our Outlook forecasters, K. S. Adams, chairman of Phillips, suggested that present indices of our industry's health were out-dated. This has always been true to some extent and has become more evident in the last three years. Economic measurements have never left the field of dispute. In the overall economics picture, we have interpretations (and even hallucinations) of national statistical data, which are themselves in question. As Professor Nadler, New York University, says of labor supply: Part of the problem is that we really do not have accurate employment statistics.

We could bungle through this confusion in less hectic days. Some companies and individuals might be hurt but the industry could weather the storm. Today, in the race to supply enormous demand, we need the taut reins of stable measurements to keep our direction true. Instead we have a patched-up conglomeration of varied colored statistics — slack here and tight there — that throws us sometimes into the grandstand (usually political) and then back into the fence (our intra-industry frustrations).

Tax conditions and government controls spread our financial reports all over the lot. Even with this distortion our soundest measurement of industry economic health are annual and quarterly corporation reports. These, however, do not include large sections of industry activity. Petroleum Equipment Supply Association does a remarkable job in statistical records of the goods the industry buys. The staff could perform a better service for the petroleum industry and its suppliers, however, with more exact measurements of particular needs.

We've suggested before a separate organization of oil and gas economists who could pinpoint the divergence in methods of statistical records and try to coordinate them. There are many good data — from API, IPAA, U. S. Bureau of Mines petroleum branch, AGA, for example — but there are gaps and disagreements that need study and proposals for changes to give us a clear picture of where we stand and where we're going.

We believe we need a revolution in economic thinking for our industry and, more importantly perhaps, for our nation. For action our first move should be in our own bailiwick — the oil and gas industry.

We act like a crew that found every thread in its drill pipes different. Is it beyond reasonable people to thread standards for economic indices so we can evaluate and build on more solid ground? — *Ernestine Adams*

***Congrats and $25 for this quip to FABIO SORIA GALVARRO, Compañia de Perforaciones, S. A., Casilla 1215 — La Paz, Bolivia.***

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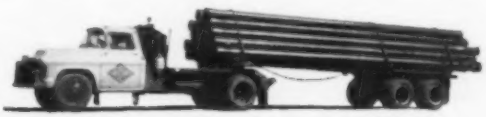

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# petroleum profile

IT'S HARD TO DECIDE whether M. H. Robineau should be described as an oilman or a sportsman. He makes pretty much of a career out of both, and at one time in his younger days his Dad forced him into making his living as a banjo player.

At the present time Mr. Robineau is chairman of the board and president of The Frontier Refining Company, president of the Wyoming-Nebraska Pipe Line Company, president of the Florida Southern Oil Company, and president of Western States Refining Company.

He and his wife have also been in the horse racing business since 1952, racing thoroughbreds in New York, Florida, Illinois, Nebraska, Colorado, Arizona and California. Their stable consists of eleven horses. Not only that but Mr. Robineau continues to play tennis, primarily doubles. Last year he and Gardnar Mulloy, as partners, won the U. S. National Senior Indoors title and the European Senior Doubles title, as well as several other tournaments. This year they reached the finals in the National Indoors, and the Quarter-finals in the National Senior Doubles at Brookline, Massachusetts.

**M. H. ROBINEAU**
*Chairman and President*
*The Frontier Refining Company*

Robineau arrived with the Twentieth Century in Syracuse, New York, at 204 Robineau Road, a residential street named after his father, Samuel Robineau. The senior Mr. Robineau was a naturalized U. S. citizen from Paris, France, who originally came to New Orleans in the 1890's as a cotton broker, moved to the Red River Valley in North Dakota as a wheat farmer, and finally to Syracuse, New York, where he was editor of Keramic Studio, an art magazine. Mr. Robineau's mother was Adelaide Alsop Robineau, a world famous ceramic artist and a member of the art faculty at Syracuse University, as well as owner of the Robineau pottery.

Bud Robineau left Syracuse Central High School in his junior year, April, 1917, to join Syracuse University Hospital Unit, which was mustered into the regular U. S. Army Medical Service in August. He served 14 months overseas in England and France during World War I as a private, performing ambulance and hospital orderly duties. In addition, he was the company official bugler and played the banjo in the company "Anaesthetic Quintet," a musical organization used primarily for entertainment of the enlisted personnel, but sometimes used for "anaesthetic" purposes during drives when the actual chemicals needed were in short supply. Following the Armistice, this quintet, which had grown to 9 members, became known as the "Original A.E.F. Jazz Band" and was transferred to the Entertainment Service, touring the various rest camps in Europe.

When mustered out of service in March, 1919, Bud Robineau returned to Syracuse Central High and by working with a tutor and by attending Syracuse University summer school, he succeeded in entering Sibley College of Cornell University in the fall of 1919 as a mechanical engineering student.

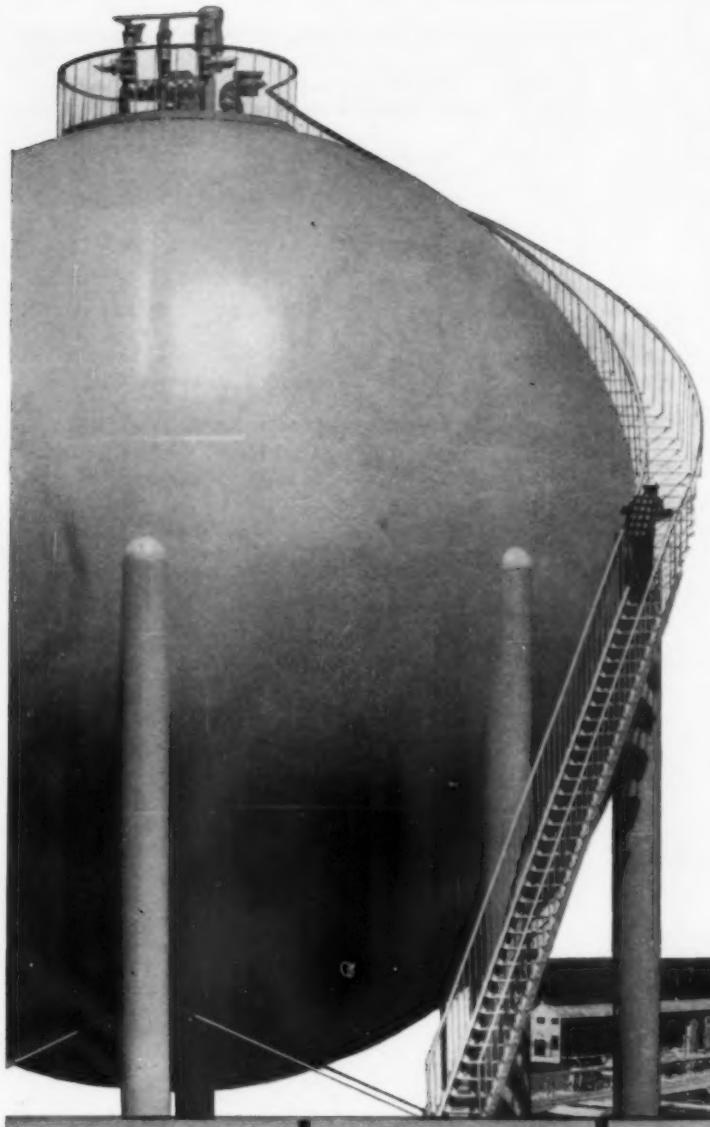
During his year at Cornell he was a member of the Cornell freshman track team, tennis team, and first string catcher on the Cornell freshman baseball team, maintaining "A" grades in his studies. He joined Delta Upsilon fraternity and kept up his banjo playing as an amusement rather than a means of livelihood. He also lived rather well and spent all the money in one year that his father had set aside for a 4-year course. The result was that his father told him if he wished to complete his college education he would have to earn his own way. Bud hesitated to return to Cornell as a working student after acting such a "big shot" the previous year, and therefore transferred to the Colorado School of Mines in the fall of 1920, securing the degree of Engineer of Mines in 1923. He earned his way through school playing the banjo with his own orchestra — in fact made more money during his student life than he earned for 2 years as a graduate engineer. He was elected a member of Theta Tau, an honorary engineering fraternity, and made eight letters in baseball and tennis. He played on the football squad but did not make a letter.

Following graduation, he went to work for The Texas Company in western Nebraska in the sales department as there was no opening at the time in the geology department. In 1925 he went in the jobbing business with his family as the Western Nebraska Oil Company. He built this company up to seventh in marketing in Nebraska, and still had time to manage his own baseball, softball, semi-professional football teams, and play tennis in the winter-time in the International Circuit on the Riviera of France.

In 1930 he married Fannabelle Zike of Sidney, Nebraska and they have three children, Germaine, Rick, and Michael, and five grandchildren. Ever since 1940 Mrs. Robineau has also acted in the capacity of one of his secretaries, primarily when traveling.

He formed the Bay Petroleum Corporation with Mr. C. U. Bay of New York in 1934 and resigned five years later to form Frontier Refining, and has been president and general manager of that company since that date.

Although sports occupy a large part of his time, he still serves his industry. He is president of the Independent Refiners' Association of America; a director of American Petroleum Institute and a member of the National Petroleum Council.

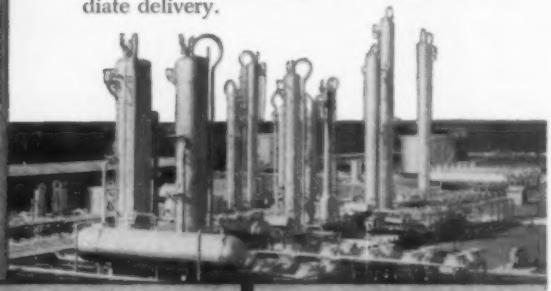


# Tough, colorful, lasting beauty!

Take those pumps and rigs in the oil fields—or those tanks and pipelines in the refineries! Each needs the tough, colorful, lasting beauty that Rust-Oleum provides. If the surface is rusty, Rust-Oleum 769 Damp-Proof Red Primer can be applied *right over the sound rusted surface* after removing rust scale and loose rust. Special Rust-Oleum Oil Field Finishes match the original equipment colors on pumps and rigs – while other long-lasting Rust-Oleum coatings protect costly tanks and pipe lines.

They're specially made for oil field use – tough, flexible, easy-to-use on the spot by brush or spray! They dry to firm, glossy finishes that resist sun, fumes, heat, moisture, weathering, and blowing dust and sand.

Try Rust-Oleum . . . your Rust-Oleum Distributor maintains complete stocks for immediate delivery.



Apply Rust-Oleum 769 Damp-Proof Red Primer directly over sound rusted surfaces.

Follow-up with the Rust-Oleum finish coating in the color of your choice

By brush or spray – the Rust-Oleum system provides tough, colorful, lasting beauty.

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There is only one Rust-Oleum. Distinctive as your own fingerprint.

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- ☐ Free test sample of 769 Damp-Proof Red Primer to be applied directly over sound rusted surfaces.
- ☐ Complete literature with color charts.

# the conference table

**Signal Has Its Own Helistop**

The first private rooftop landing facility for helicopters in Los Angeles is on Signal Oil and Gas Company's new 16-story building at Wilshire and Beaudry. The unique helistop (see photo above) will afford quick transportation to and from airports and company operations throughout Southern California, said Russell H. Green, president.

Signal has made the centrally located landing pad available in emergencies to Civil Defense agencies and the police, fire, and sheriff's departments, Green said.

*A man who causes fear cannot be free from fear.* — Epicurus.

**Czech Bicycles Dumped in U. S.**

The Anti-dumping Act was successfully invoked by the U. S. Bicycle Manufacturer's Association when bicycles from Czechoslovakia were sold in American market at prices below fair value.

The Anti-dumping act is seldom used. Evidence compiled by BMA was submitted to the Treasury Department which launched the case in December, 1959 and returned a finding of dumping.

*If you keep your mind sufficiently open people will throw a lot of rubbish into it.* — William A. Orton.

**Management's Job**

"The primary responsibility of the officers and directors of a company is to render that company successful, to cause it to make money. It is their job to do so under severe difficulties. Competition will be intense, labor will sometimes be unreasonable, customers will be fickle, bureaucrats will be oppressive, laws will be absurd.

"In spite of hell and high water, within the limits of the law, and with decency and just dealing, it is the prime duty of management to make a profit. Unless it does, it will not long be present to do anything else.

"But, for a successful company this is not enough. It is not enough, for one reason, because, in a democratic society and in the long run, a corporation will not be allowed to exert its great economic power without harassment, unless the public believes that it is operating for the public benefit."

From a paper "Business Management — A Profession" by Vannevar Bush, chairman, Merck & Company, presented before Manufacturing Chemists' Association, Inc., November 22, 1960, New York City.

**U. S. Foreign Aid**

Total foreign aid outlays by the U. S. Treasury since World War II add up to $78.5 billion, through March 31, 1960.

The current recapitulation, from a tabulation by the Office of Business Economics, Department of Commerce, includes military assistance, economic aid, all government credits, plus all surplus farm products delivered abroad for blocked currencies. Not included are U. S. military payrolls overseas nor the direct U. S. administration costs of some thirty different foreign aid programs under direct U. S. supervision and control.

The fifteen-year breakdown, by types of aid:

| | |
|---|---|
| Economic assistance | $47.9 billion |
| Military assistance | 25.8 " |
| Capital subscriptions (International credit agencies) | 4.8 " |
| Total | $78.5 " |

The table below shows the combined total to each of the principal nations assisted by the various U. S. programs:

**U. S. FOREIGN AID**
(October 1945 through March 31, 1960)

| | *Millions* | | *Millions* |
|---|---|---|---|
| France | $9,709 | Libya | 113 |
| United Kingdom | 7,722 | Morocco | 106 |
| Italy | 4,834 | Sweden | 105 |
| Germany | 4,584 | Afghanistan | 98 |
| Formosa | 4,381 | Guatemala | 94 |
| Korea | 3,755 | Finland | 87 |
| Japan | 3,178 | Tunisia | 77 |
| Greece | 2,739 | Lebanon | 70 |
| Turkey | 2,642 | Iraq | 69 |
| Netherlands | 2,091 | Ethiopia | 64 |
| Yugoslavia | 2,026 | Burma | 64 |
| Belgium-Luxembourg | 1,867 | Ecuador | 63 |
| Vietnam | 1,572 | Haiti | 60 |
| India | 1,386 | Iceland | 54 |
| Philippines | 1,189 | Cuba | 53 |
| Austria | 1,092 | Trust Territory of Pacific Islands | 52 |
| Spain | 980 | Liberia | 52 |
| Norway | 892 | Ceylon | 52 |
| Indo-China | 821 | Costa Rica | 47 |
| Iran | 813 | Uruguay | 40 |
| Brazil | 782 | Panama | 32 |
| Pakistan | 778 | Rhodesia | 32 |
| Denmark | 719 | Paraguay | 28 |
| Poland | 654 | Hungary | 27 |
| Israel | 596 | Nicaragua | 24 |
| Thailand | 480 | Honduras | 22 |
| U.S.S.R. | 423 | Albania | 20 |
| Indonesia | 408 | Saudi Arabia | 18 |
| Portugal | 368 | Sudan | 17 |
| Mexico | 321 | East Germany | 17 |
| Laos | 261 | Nepal | 17 |
| Peru | 257 | New Zealand | 12 |
| Ryukyu Islands | 237 | El Salvador | 9 |
| Argentina | 229 | Dominican Republic | 8 |
| Cambodia | 228 | Venezuela | 7 |
| Chile | 228 | Yemen | 5 |
| Egypt | 208 | Somaliland | 4 |
| Colombia | 202 | Ghana | 3 |
| Jordan | 194 | Guinea | 2 |
| Czechoslovakia | 191 | Malaya | 1 |
| Bolivia | 181 | | |
| Ireland | 142 | | |

—*Lawrence Sullivan*, Coordinator of Information, U. S. House of Representatives

# Exclusive LUFKIN Chrome Clad® lines won't rust, chip or peel

**The bold, black markings are bonded to steel** . . . protected by layer on layer of electroplating . . . topped by a final coat of chromium!

**Exclusive quality features** are yours in all Lufkin tapes. For example:

**Lufkin "Atlas" Gaging Tape** (above, left) is easy to read with durable, jet-black markings on glare-free, chrome-white line. Extra *sturdy* line, 50% heavier than standard weight. 20-ounce plumb bob. Lock-handle frame.

**Lufkin Chrome Clad Anchor Tape** (above, right) is available with easy-to-read markings in feet, tenths and hundredths, in genuine-leather, hand-stitched case. The handiest thing you can carry, on job after job.

See your Oil Supply House.

*Measure for measure, the finest made...*

LUFKIN

SAGINAW, MICHIGAN

**It's That Decimal Again**

The decimal got out of hand in the article "Petroleum Powers Western Europe Economic Boom," page E-2, in the November issue. Here is how one of our readers set us straight.

Dear Sir: Gasoline is not cheap in France. But according to your arithmetic, we would pay for a gallon of high grade gasoline the equivalent of:

$$\frac{2.04}{100} \times \frac{104}{0.2642} = \$\ 8.03/\text{gal.}$$

We consider that $ 0.803 is enough!

1 new franc = 100 old francs

1 old franc = 0.204 cents

*J. Cottin*
*Le Chef du Service Forage*
*Batignolles-Chatillon*

**School for Engineering Executives**

Forty high level executives have enrolled in a University of California 6-week course designed to train scientific and industrial leaders in making technical decisions. The advisory and instructional staff includes Dr. Edward Teller, Dr. Willard Libby and Coordinator J. Morley English, professor of Engineering at UCLA.

English says the engineer executive technical knowledge tends to become out-dated so fast that within sixteen years after he has completed his education, his knowledge of facts, his concepts of methodology in design and other details are just about half of those which the newly-graduated engineer possesses.

This intensive course where the enrollees will go to class six days a week with evenings devoted to supervised study in the semi-isolation of Ojai Valley will cost $2340.

*Socrates was a Greek philosopher who went around giving good advice. They killed him.*

**Fuel Policy Advocates Push Program**

In a 3-page release the National Coal Policy Conference pressed again for a domestic fuel conservation and utilization program. We've always assumed our national fuels policy was that the most efficient, both from performance and cost, would be the fuel that was used by consumers and industry. That doesn't satisfy our planners.

Joseph E. Moody, president of National Coal Policy Conference, says Congress must adopt a national policy to assure a sound self-sufficiency for our own protection and to guarantee orderly growth.

He points out that platforms of both political parties advocated it; that two important national study groups advocated it; that the Task Force on Distressed Areas headed by Senator Douglas recommended it; that the Landis Report on Administrative Agencies demanded national policies in energy and concluded with President Kennedy's pre-election declaration: "When (the new) President enters the White House in January . . . no problem will more urgently demand his attention than the problems of our fuels industries — and the coal industry in particular. If he is to meet these problems effectively — if his decisions are to weigh every factor and weigh them equitably — that President will need a National Fuels Policy."

That's a lot of political argument on one side.

*Gold is tested by fire, man by gold.*

**Free Foreign Demand Up 7% to 8%**

Here is a forecast statement from R. G. Follis, chairman of the board of Standard Oil Company of California. It was received too late for our January Outlook. Regardless of that we believe you will be interested. Mr. Follis stated:

"The year 1961 should open with American economic activity continuing to fall off slightly, a trend which began in mid-1960. Inventory reductions, cutbacks in plant and equipment expenditures, and declines in consumer purchases of durable goods will probably cause some further slackening in production during the next few months.

"This downward swing of business should reverse itself by mid-year. Reversal of the inventory cycle, modest increases in construction, growth of government expenditures, and increases in consumer purchases of nondurable goods and services are expected to lead to an upturn by summer. The year to come should end with business activity recovering and at higher levels than now, though still short of full-capacity or boom conditions.

"The petroleum industry is experiencing a temporary slowdown in its growth rate because of general economic conditions. The business recovery anticipated in the last half of 1961 will benefit petroleum sales and for the year as a whole total domestic demand will probably show a modest gain, though somewhat under the 2% increase recorded in 1960.

"Free foreign petroleum demand is expected to rise by 7% to 8% in 1961. Although this percentage gain is not as large as the 11-12% increase in 1960, it still represents a substantial gain from a volume standpoint, and indicates a continuation of the rapid growth in petroleum demand which has been occurring in recent years abroad. As evidence of this, total demand in the Free foreign areas averaged 9,080,000 b/d in 1960, compared to 5,995,000 b/d in 1955 and 3,499,000 b/d a decade ago.

"In 1961, Standard of California will again spend about $400 million in its capital and exploratory programs, approximately the same amount as in 1960."

**Names National Petroleum Council**

Secretary of the Interior Fred A. Seaton early in January appointed 111 leaders in the oil and gas industry to the National Petroleum Council. There were not many changes from 1960. The following are new appointees: Terry Bass of Fort Worth; Paul M. Howell of San Antonio; Harry A. Jackson, president of Petrofina; Don H. Miller, president of Skelly; Monroe E. Spaght, Shell Oil; Richard L. Vockel, vice president of Waverly Oil Works Company.

The Council was established 14 years ago as a liaison between industry and government. Walter S. Hallanan, Plymouth Oil, has been chairman since the organization.

*It's so cheap to do things when you know what to do.*

**Oil Industry Stocks Favored**

An analysis of the oil industry by Perspective, a publication of Calvin Bullock, said the post-war investment history of the oil industry came in three cycles.

In the first one, which came at the end of World War II, the oil industry entered the post-war boom era with much of its plant obsolete and a shortage of capacity to meet estimated future demands.

The second cycle, which began in late 1957, followed the strain of the Suez crisis and from then on oil industry earnings began to decline rapidly.

Now, says the report, the third oil investment cycle has gone into effect and this "is the only sensible one in the entire post-war period."

# Good Wells Make Good News

## A Report on Some Unusually Successful Recent Frac Jobs

**February, 1961**

Here are four recent examples showing how Dowell fracturing services have helped operators increase oil and gas production and profits.

- **Butler County, Kansas** (Waterflood Producer) Production from this Kansas City lime well had declined to 4 bopd and 30 bwpd. Dowell engineered a treatment using the Frac Guide*. 5000 gallons of acid-oil emulsion carried 10,000 pounds of 20-40 mesh sand into the formation at 12 bpm. 140 days after treatment, production was 81 bopd and 106 bwpd.

- **Panola County, East Texas** (Old Gas Well) Gas delivery from this well into the 300-psi line had declined to 200 mcfd. The well had been producing from eight perforated intervals between 6068 and 6434 feet in the Travis Peak formation. The total perforated pay was 111 feet -- 70 of which looked good on logs. Dowell engineers fractured the well using 100,000 gallons of gelled water and 70,000 pounds of 20-40 mesh sand -- 1000 pounds sand per foot of good pay. As each interval was fractured, perforation ball sealers were injected to divert fracturing fluids to another zone. Injection rate averaged 24 bpm at pressures ranging from 2500 to 4000 psi. After treatment, delivery to line was 1200 mcfd, a net increase of 1000 mcfd. Payout was fast -- approximately 1½ months.

- **Jones County, Northwest Texas** (New Oil Well) This tubingless completion was made into the Canyon sand through five sets of perforations between 3864 and 4039 feet. Initial test was almost two boph but operator wanted to stimulate so top allowable would be assured. Dowell engineered a treatment using the Frac Guide. 40,000 gallons lease oil with FLA* (Fluid Loss Additive) and 80,000 pounds sand were injected down 2⅞-inch casing at 12 bpm and 3400 psi. After treatment, well potentialed 1560 bopd -- a 30-fold increase.

- **San Juan County, New Mexico** (New Gas Well) This development well was drilled into the Dakota sand between 6698 and 6774 feet. Permeability was so poorly developed, compared to other wells in the area, that abandonment was considered. However, operator decided to complete the well, using Abrasijet* -- abrasive jetting service -- and fracturing. With Abrasijet, Dowell cut five notches into formation at 6698, 6704, 6756, 6768 and 6774 feet. About 20,000 pounds of sand was used. Dowell then fractured using water to carry 30,000 pounds of sand at about 35 bpm. Well potentialed 2500 mcfd -- similar to other wells in the field. Operator believes $4500 treatment made an economic producer out of what would otherwise have been a dry hole.

Your Dowell engineer has many services and products to help you improve net profits on your operations. For service or more information, dial Dowell. Dowell services and products are offered from more than 150 offices and stations in the United States, Canada, Venezuela, Argentina, Germany, France and the Sahara area. Dowell, Tulsa 1, Oklahoma.

*DOWELL TRADEMARK

*Services for the oil industry*

DOWELL

DIVISION OF THE DOW CHEMICAL COMPANY

# NEW

## CLAYTON MARK

# Parkerized FITTINGS

- **RUST PROOF, CORROSION-RESISTANT**
- **CARBON AND ALLOY**
- **SCREWED AND SOCKET WELD**
- **2000, 3000, 4000, 6000 p.s.i.**

Now you can buy a complete line of *Parkerized* Fittings from the same source that has supplied you with high pressure Unions and Valves since 1912. In sizes $\frac{1}{8}$" to 4", these forged steel, clean-looking fittings resist corrosion "forever" on shelf or in high-pressure steam, water, oil, gas and air applications. Eliminate duplicate paperwork . . . order all your piping requirements from your Clayton Mark Distributor. Have the best yet save time and money —specify Clayton Mark!

**AVAILABLE IN 50 STATES AND THROUGHOUT THE WORLD**

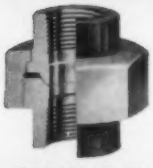
# CLAYTON MARK

AND COMPANY

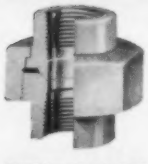
1914 DEMPSTER STREET · EVANSTON, ILLINOIS · U.S.A.

PUMPS · WATER WELL SUPPLIES · CONDUIT · UNIONS · TUBING

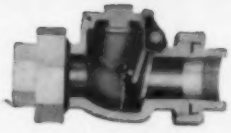
## HOT FORGED STEEL HIGH-PRESSURE UNIONS AND VALVES



"PETRO" CARBON STEEL UNION



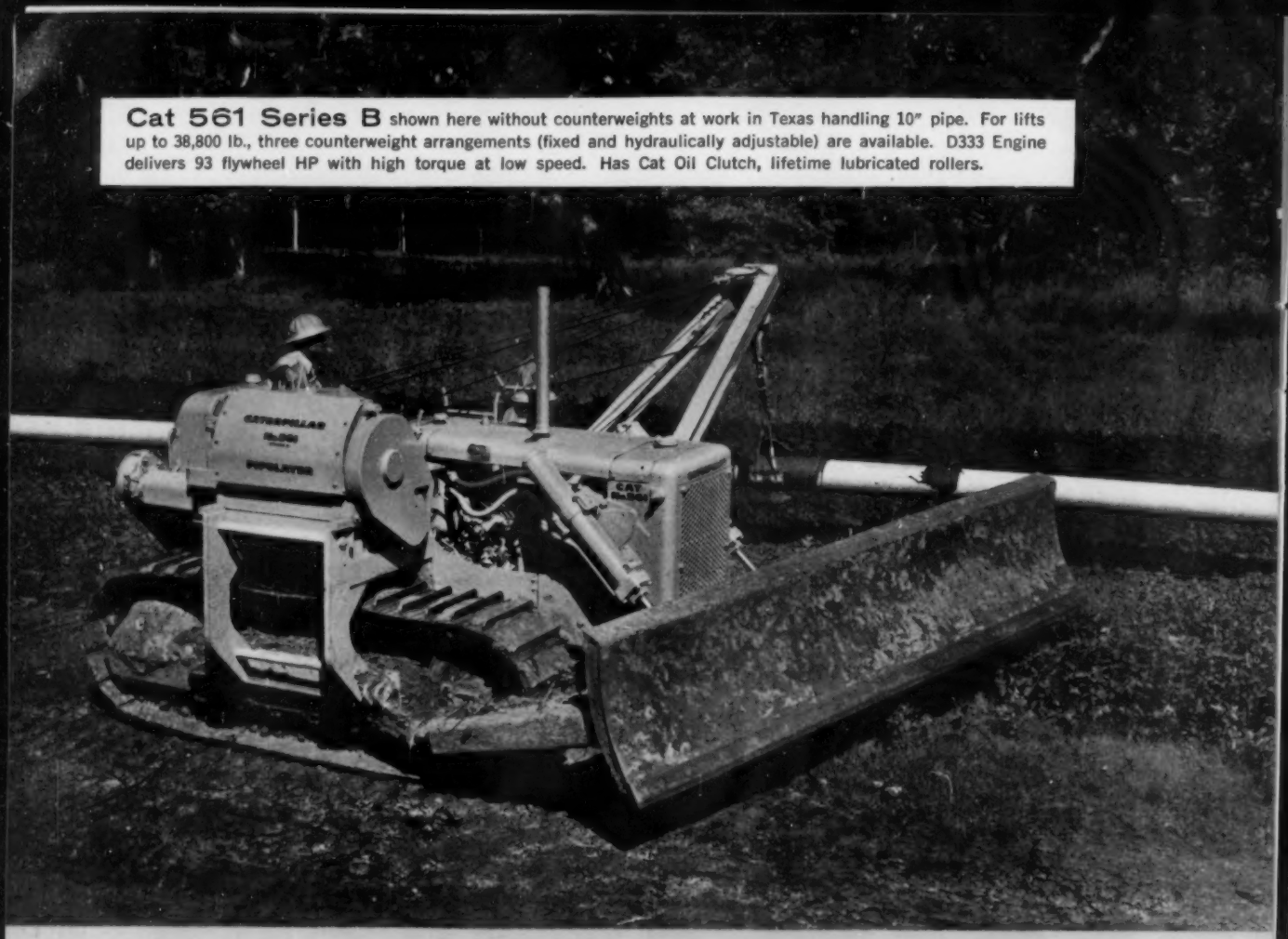
PETRO" STAINLESS STEEL UNION



SWING CHECK VALVE

"PETRO" CHECK VALVE

"BEVELED" ORIFICE UNION



**Cat 561 Series B** shown here without counterweights at work in Texas handling 10" pipe. For lifts up to 38,800 lb., three counterweight arrangements (fixed and hydraulically adjustable) are available. D333 Engine delivers 93 flywheel HP with high torque at low speed. Has Cat Oil Clutch, lifetime lubricated rollers.

# MD7 AND 561 PIPELAYERS
# ...Caterpillar makes 'em

**TAKE THE CAT 561 PIPELAYER**—G. W. Townsend Lease Service (Bay City, Texas) used a 561 to lay four miles of 10" and 12" natural gas line for Pan American Petroleum Corp. near Sweeny, Texas. In open country, 600' of pipe was lowered into a 48" by 24" ditch in two hours. In close quarters, an average of 2000' of pipe was lowered in daily.

What do the Townsend people think of the 561? They like the way it handles. They like its balance and the way it responds—fast and accurately. The operator singled out the placement of controls. They're in easy reach, without stretching. Their location permitted him to keep his eyes on the work as he moved along the ditch.

With an angle filler up front, Townsend's 561 takes on extra jobs—backfilling and other utility work. (Another contractor put a No. 6A blade on his 561, uses it for right-of-way clearing. The 561's integral hydraulic system—optional—makes it easy to handle a blade, keeps pump and valves under the hood out of the way.)

All in all, the 561 does the kind of job you expect of Cat Pipelayers. *Dependable*—work done quickly and economically.

**OR TAKE THE MD7**—Ford, Bacon & Davis Construction Corp., Monroe, La., had about 30 miles of 12" pipe to lay south of Welsh, La., for

**Cat MD7** is shown cradling pipe in Louisiana marshland. The Series D MD7 has greater power (140 flywheel HP and 54,200 lb. lifting capacity), improved torque rise (boosts lugging ability by 80%), and there's a new dry-type air cleaner, new, stronger final drives, and many other advantages to boost production and lower costs.

# to make money for you

the Louisiana Pipeline Company. The route met an average of three irrigation canals per mile, in addition to Louisiana bayous and swamps. Even so, with three new Cat MD7 Pipelayers in the spread, 4000′ to 5000′ were laid every day.

The MD7's seven-roller track frame and 22″ track shoes give the new Cat Pipelayer exceptional stability and flotation needed in swamps and bayous. No wonder, then, that Ford, Bacon & Davis are pleased with the performance of the new MD7s. They bought them for high production under tough conditions. And that's what they're getting.

These new Cat Pipelayers have what it takes to turn in performance records even better than previous models. Extra production slashes operating and maintenance costs . . . see your Caterpillar Dealer for the whole story on the new pipelayers. Ask for an on-the-job demonstration.

Caterpillar Tractor Co., General Offices, Peoria, Illinois, U.S.A.

**CATERPILLAR**

Caterpillar and Cat are Registered Trademarks of Caterpillar Tractor Co.

**MODERN, HEAVY-DUTY PIPELAYERS FOR THE HARD WORK**

"Until world tensions lessen, the paramount call on our resources must continue to be for the protection of our freedom.... If undue preoccupation with the pursuit of comfort and convenience should blind us to this over-riding need, we could end up by having neither comfort nor freedom."

– Leo D. Welch, Chairman of the Board

**Standard Oil Company (New Jersey)**

(PRINCIPAL U S. OPERATING AFFILIATE: HUMBLE OIL & REFINING COMPANY)

# *Now!* The LUNKENHEIMER BALL VALVE

**Fig. 700-T**
¼″ to 2″, Screw Ends, Bronze Body, Teflon Seats and Seals.

**Fig. 700-B**
¼″ to 2″, Screw Ends, Bronze Body, Buna-N Seats and Seals.

**AVAILABLE SOON in OTHER MATERIALS**

## New Top-Entry Design

Engineered with traditional Lunkenheimer quality . . . self-aligning ball seals against both seats . . . long-lasting resilient seats for tight shut-off . . . straight-through flow . . . quarter-turn operation . . . top entry for easy maintenance

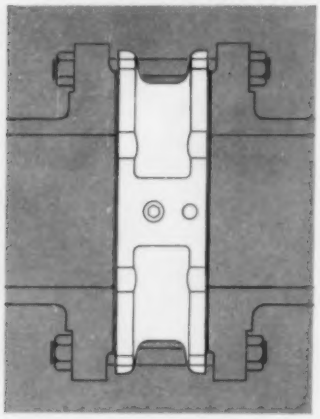
*Order from your Distributor*

or write The Lunkenheimer Company, Cincinnati 14, Ohio

L-960-3

**LUNKENHEIMER®**
THE ONE *Great* NAME IN VALVES
• BRONZE • IRON • STEEL • PVC

The Duo-Chek® is easily lowered into position between the flange faces; because of its light weight, special handling equipment is unnecessary. Fits standard valve flanges. In sizes 2 inch through 12 inch, one valve fits series 125, series 150 and series 300 flanges, saving inventory at less cost than a conventional 150 series. The machined outside diameter centers the Duo-Chek between series 300 flanges; the slots center it for series 150 flanges.



*See the Duo-Chek*
*Booth 222*
*1961 Petrochemical & Refining Show*
*New Orleans*

PAT. PENDING

# MISSION DUO-CHEK NO SLAM CHECK VALVE

If your check valve problem is water hammer, Duo-Chek is the answer. If it's weight, maintenance, mounting position, or cost, Duo-Chek is still the right answer. The Duo-Chek performs all regular check valve duties, yet weighs only ten per cent as much.

The spring loaded, light weight sealing plates operate in any position—even in vertical lines with downward flow. The stainless steel coil spring effects positive sealing action. The quick action of the spring closes the valve before reverse flow can occur; therefore, no slam, no water hammer.

Duo-Chek valves come in a complete range of end connections and sizes from 2 to 48 inches, for ASA pressure ratings of series 125 through 2500, and for temperatures to 1400°F. They are made in steel, stainless steel, aluminum, and bronze. Sealing materials are Buna-N, Teflon, Viton, or metal depending on your service.

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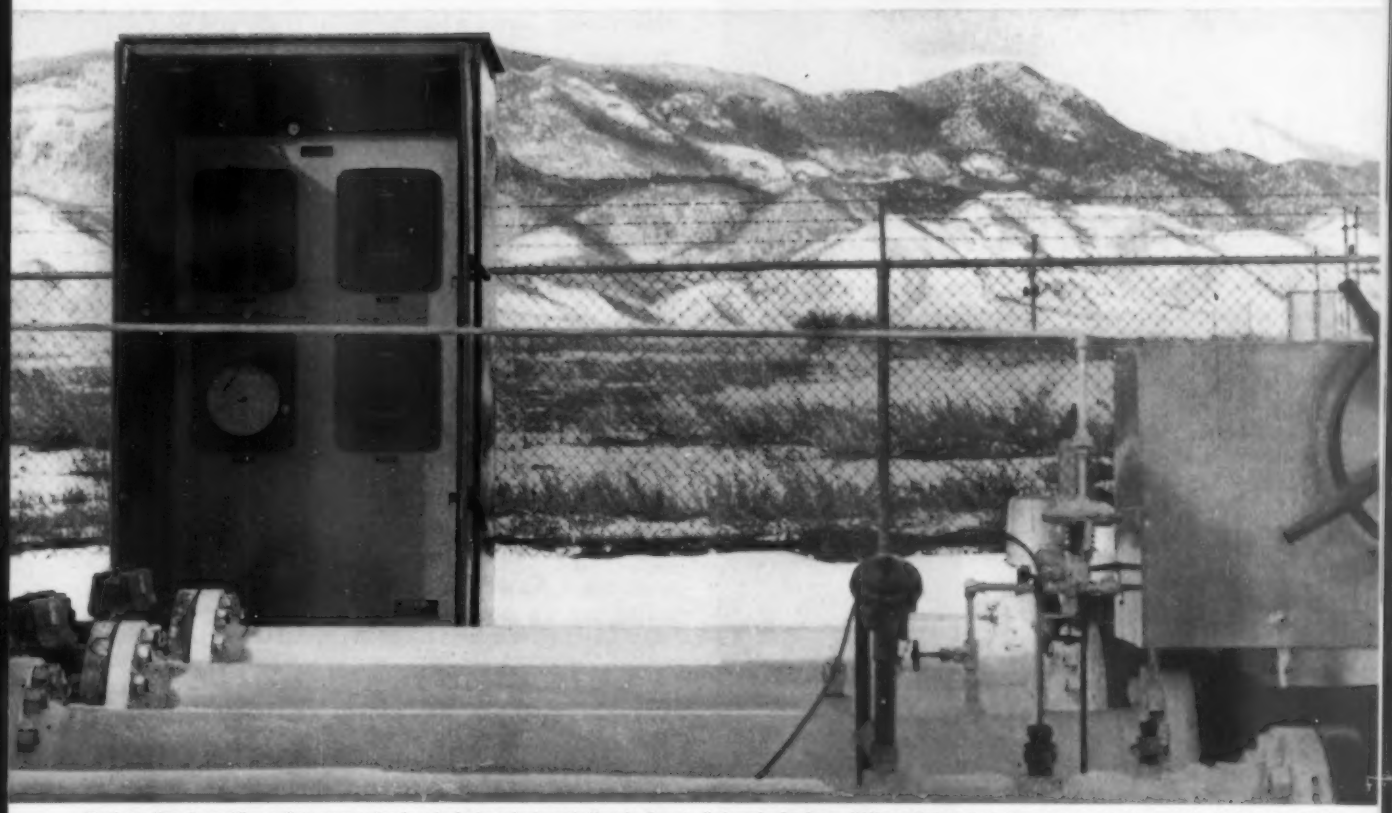
# This Colorado Interstate Dispatcher is reading gas flow data from four different states...



Foxboro "packaged" gas flow computer located at metering station in South Colorado Springs. Differential and static pressure instruments (right of panel) convert measurements to electrical inputs for the Dynalog* Computer-Telemeter (lower left). Instrument at upper left telemeters down-stream gas pressure.

## Foxboro Gas Flow Computing Systems deliver it continuously, automatically

Continuous gas flow totals from 20 metering stations, scattered across four Rocky Mountain states. That's the information Foxboro Gas Flow Computers provide for Colorado Interstate Gas Company in Colorado Springs.

Foxboro Gas Flow Computers do their computing at the metering point. Compensation for temperature and pressure is done on the spot with only total gas flow values being transmitted. Result: transmission line space is saved; errors common to systems that transmit several values are reduced.

Foxboro Gas Flow Computers are furnished as a complete "packaged" unit — calibrated and tested as a system before shipment — ready to install.

For single meter runs — for multiple runs, you can't beat the accuracy or the reliability of this Foxboro system. Ask your local Foxboro Field Engineer for details.

The Foxboro Company, 382 Norfolk Street, Foxboro, Massachusetts. *Reg. U. S. Pat. Off.*

FOXBORO

REG. U. S. PAT. OFF.

another

# TRETOLITE SERVICE report

## *Midwestern refinery "saves a bundle" with* KONTOL* *Corrosion Inhibitor*

*Before KONTOL treatment —in service 76 days*

*After 295 days' service, with KONTOL treatment.*

Both ways—in dollars and in actual equipment—this refinery "saved a bundle" in its crude unit heat exchange section by adopting a KONTOL* protection program.

Heat exchange was inefficient and tube life was short. Then KONTOL Corrosion Inhibitor was injected into the overhead line ahead of the condensers.

### *Here are the bundle-saving results:*

- Tube bundle life was *tripled* by drastic curtailment of corrosion.
- Heat savings amounted to *6,000,000 BTU's per hour*, as a result of KONTOL's powerful detergent action.
- Estimated cost of heat loss was $96 per day prior to use of KONTOL. KONTOL protection eliminated this loss for only $20 per day—a savings of nearly 5 times the cost.

*KONTOL Corrosion Inhibitors are protecting tube bundles, and saving bundles of money, for refiners all over the world. Ask your Tretolite Field Service Engineer (the "Man in the Red Car") for more details.*

*Registered trademark of Petrolite Corporation

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## Conference Table – *Continued*

**Maybe We Are Sensitive**

"How to Avoid Being Cheated — By the Pound or Gallon" is the name of an article in the October Reader's Digest condensed from Redbook. After reading this short 4-page piece I got the idea that filling stations, liquefied petroleum gas deliveries and fuel oil deliveries were the main places being cheated. If any of the devices for cheating the customers are used to any extent by marketing people, we need badly to clean house.

*"One example is more valuable than 20 precepts written in books."* — Rober Ascham.

**Takes More U. S. Oil Exports**

About $11 million increase in exports of petroleum and products to Japan was registered the first half of 1960 over the same period in 1959. The U. S.-Japanese Trade Council shows about $30 million in petroleum and products exported to Japan the first half of 1959 and $41 million in the first half of 1960.

*"Even including taxes gasoline costs only one-fourth as much as ordinary soda water!"*

TIPS from American Association of Petroleum Landmen

**Take It or Leave It**

Sometime employees need to be "shook up" to realize they are getting careless. The always pertinent "Flexsteel Newsreel" lays it on the line in a piece "We Discriminate Against Chimpanzees." Writes the editor of this Flexsteel company publication:

"At the present time the U.I.U. is trying to organize the chimpanzees in one plant. We are paying for performance that is supposed to be better than chimpanzees could do, but the performance we have been receiving much of the time leaves a lot of room for doubt. We intend to get the performance we are paying for. Sub-standard performance is going to bring a written warning. This can mean a loss of a job. If it does, the remaining employees and the company will be better off because good, careful products will bring in more business.

"If you are not a chimpanzee then you know if you are doing your work carefully and well. Integration between good craftsmen and chimpanzees is not required either by law or by our contract. We intend to discriminate."

**Is the Price Right?**

Despite the rising price trend, products and services represent a better buy today than they ever did in the past. This is the theme of "The Story of Prices," a booklet published by the Du Pont Company. You can get a copy by writing E. I. Du Pont de Nemours and Company, Public Relations Department, Wilmington 98, Delaware. This is one of a series of excellent books Du Pont has produced dealing with ecoonmics. We recommend them all.

Living standards, as measured by the consumer's ability to buy the things he needs and wants, the booklet says, are the highest the world has known at any time or in any place.

The 32-page illustrated booklet describes the price structure as "an inseparable part of the American economy, an economy that is at once consumer controlled and consumer centered," and shows how the price structure evolved to meet the growing and changing needs of the American people.

Throughout history, it says, every society has been concerned with the price structure, and has sought to maintain some controls over it. Yet people usually found it just as difficult to live with price controls as without.

"Only in the past 150 years, in free nations such as the United States," the booklet says, "has man been able to develop an economic system which liberates him from arbitrary action in the price area, and which provides the means to fill his many and diverse needs. After many millennia, he found how to produce two loaves of bread instead of one."

*It's the little things that annoy us. We can sit on a mountain but not on a tack.* — Hubbard.

**Name Change**

The corporate name of Cities Service Oil Company (Del.), with headquarters at Bartlesville, Oklahoma, will be changed to Cities Service Petroleum Company. This company will supervise all domestic and Canadian exploration, production and related activities of the corporation. Robert L. Kidd is chairman of the board and chief executive officer, and J. E. Heston is president.

The consolidation of exploration, production and related activities follows the exemption on December 23, 1960 of Cities Service from the Public Utility Holding Company Act to which it had been subject since 1941. Consolidation of Cities Service marketing activities and operations under a single subsidiary was announced on December 27, 1960.

*We propose that President Kennedy name a "task force" to determine where we will get the money to cover the programs of his other "task forces."*


**Yours free!**

**Pipeline Handbook**

Special February Handbook Issue presents both practical and academic data in a concise, easy-to-read form; including tables, charts, nomograms, and examples of problems on

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# MANAGEMENT CAN AID PROFESSIONALISM

**Responsibility for the stature of a scientist or engineer rests first with the individual; second, with his university professors, and third, with industrial management.**

**L. C. Kemp, Jr.**

An important factor of interest to scientists and engineers and their managements is "professional unionism" or what might better be designated as the "unionization of professionals".

In the chemically oriented industries we are inclined to be a little smug about the fact that we do not work our scientists and engineers under conditions which we regard as conducive to unionization. As a rule, we do not, (as is frequently the case in the aircraft and electronics industries) have large teams of professional people employed on rather limited objective projects. Contributions of the individual scientist or engineer and even his identity can become completely obscured from the administrative people only a level or two above that of his immediate supervisor.

We must, however, take note of two sets of facts:

*1. There are substantial blocks of non-supervisory scientific and engineering personnel in our industries that have placed their economic and professional welfare in the hands of some sort of collective action group.*

*2. Leaders of labor unions have taken note of the declining ratio of blue to white collar workers in industry and of the ever increasing importance of the professional segment of industrial personnel. It is a well publicized part of labor union strategy to bring as many non-supervisory professional scientists and engineers into the union ranks as they can.*

In light of the highly individual nature of the truly professional man's work it can only be concluded that the scientist or engineer has little to gain and could lose much by placing his economic and professional fate in the hands of a collective agency.

Most management people will agree with this conclusion. Being against something is hardly enough, however. Positive and enlightened activity should be undertaken in the best interest of both professional people and their companies.

A considerable part of the responsibility for the professional stature of a scientist or engineer rests with the individual and to some extent with those in the university under whom he has acquired the basic skills of his profession. Industrial management also has an important role in this activity.

Managements with their stake in maintaining the profitability of the enterprises under their charge have, in general, been not only willing but anxious to assume their share of this responsibility. They know scientists and engineers are vital to the satisfactory operation of any industrial enterprise. They realize the costs of supporting such personnel have risen to such a level that management must see that professional skills are utilized in the most effective manner possible.

Profit-oriented objectives of management on one hand and the desire of scientists and engineers to concentrate their attention on technical matters on the other is assumed to be a natural cat and dog relationship.

In fact, activities of scientists and engineers are, of course, more closely related to those of management from a standpoint of the training and judgment required than they are to those of the operator or maintenance man. It is also true that many scientists and engineers ultimately find themselves in management positions. It would be difficult, however, to convince many non-supervisory scientists and engineers that they are truly a part of management. And, frankly, few realistic managers would so consider them.

This raises the suggestion that management would be well advised to consider that they are dealing with a highly valuable group of personnel and that neither the general procedures for the administration of supervisory personnel nor those for labor are apt to produce the most effective operation of technical people. Certain policies and procedures designed specifically for the administration of personnel in technical activities appear to be well justified.

In a more specific vein, here are some helpful things that alert managements have done:

*1. Established titles that clearly differentiate the professional scientist and engineer from the sub-professional personnel in the organization.*

*2. Provided lines of advancement based on technical competence in addition to the avenues of promotion in supervisory positions.*

*3. Provided adequate tools and facilities for conduct of professional work. Adequate stenographic and clerical assistance, for example, minimize the amount of professional man-hours diverted to non-productive effort.*

*4. Encouraged professional development through study of current technical literature, participation in technical society activities including attendance at technical meetings and, where practical and appropriate attendance at advanced university courses.*

*5. Emphasized individual nature of professional work and the importance attached to contributions made by individuals to company success.*

*6. Gave suitable recognition, preferably of an appropriate public nature, to outstanding individual accomplishments.*

Much has been accomplished along these and similar lines. It is in management's own best interest that the subject continues to receive the most thoughtful consideration of all administrative people.

Summarizing:

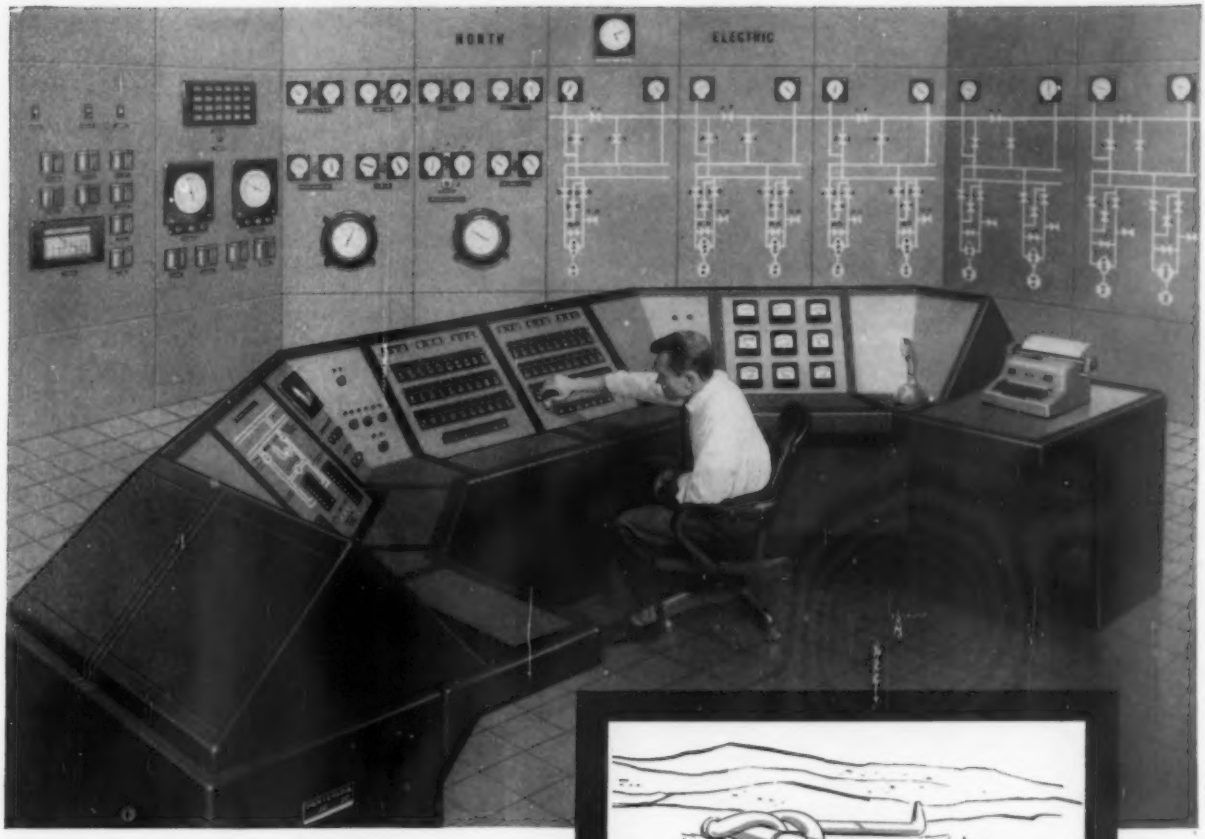
*Our scientific and engineering personnel will be subjected to an increasing extent to the organizing pressure of unions.*

*Such collective action is believed to be detrimental to the best interests of the individual and to the enterprise in which he is engaged.*

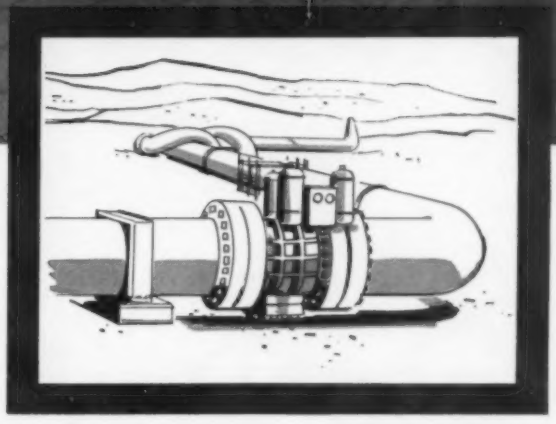
*Much more can be gained by the individual through development as a professional man.*

*Management has a vital stake in fostering this professional development by means which are reasonable in cost and relatively simple to employ.* ★ ★

Mr. Kemp is vice president of research, Texaco, Inc. This is an abstract of remarks he made on a panel concerning "Professional Attitude of Chemists and Chemical Engineers" at a meeting of Manufacturing Chemists' Association in New York City, 1960.




# North's new PARICODE™ SYSTEMS will bring better pipeline control to your operation



North's new PARICODE system has been specifically designed for the pipeline transmission and petro-chemical industries—specifically designed to perform all the functions required of automatic control and supervisory equipment—specifically designed to be fail-safe and reliable over microwave and carrier channels, or any other communication channels (including mixed channels)!

North PARICODE systems, designed on North's integrated system concept, provide for automatic sequencing and load control; data logging, handling and display; telemetering of flow data; and operation of remote unattended compressor and booster stations.

North PARICODE systems are the natural result of imaginative engineering from the company with the greatest background of experience in automatic remote control system design and manufacture.

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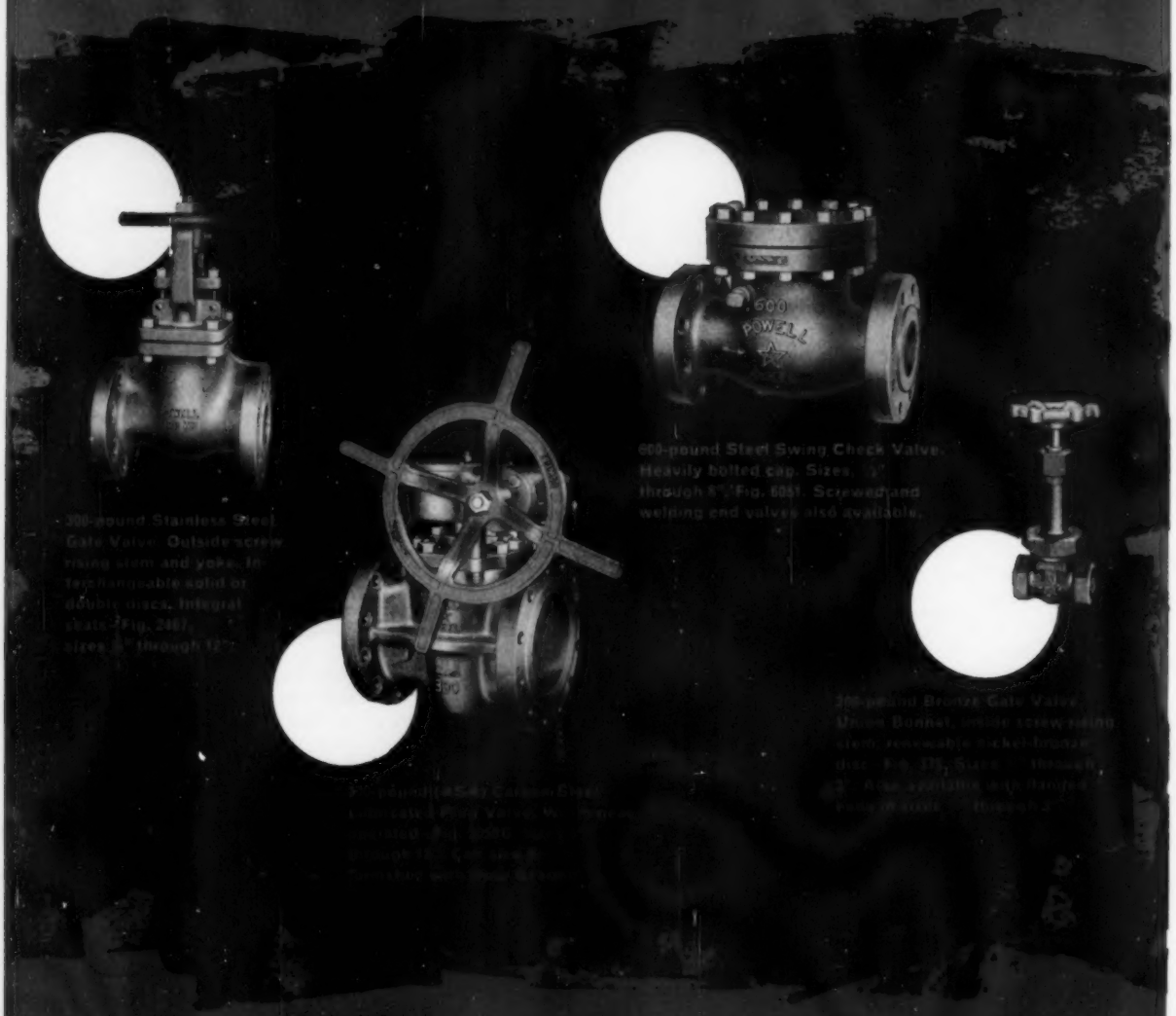


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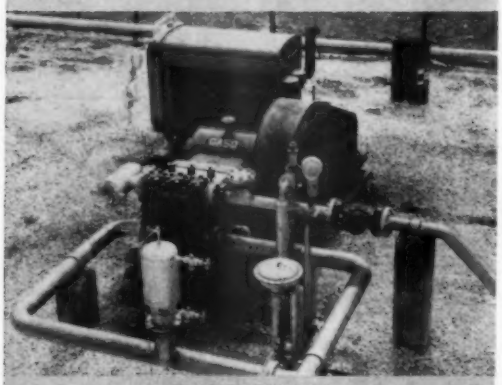
Not too long ago Gaso Pumps were known principally for their work in pipe line service.

Today they are specified in ever increasing volume by all branches of the industry.

The reason is obvious: Engineers concerned with water flooding, salt water disposal, oil well cementing, oil well acidizing and fracturing, LPG underground storage, mine water disposal and other operations involving pumps are just as interested as pipe line engineers in the extra years of trouble-free service which have become a Gaso trademark.

Performance speaks a universal language, and it's performance upon which Gaso leadership is built.

GASO PUMPS IN PIPELINE SERVICE



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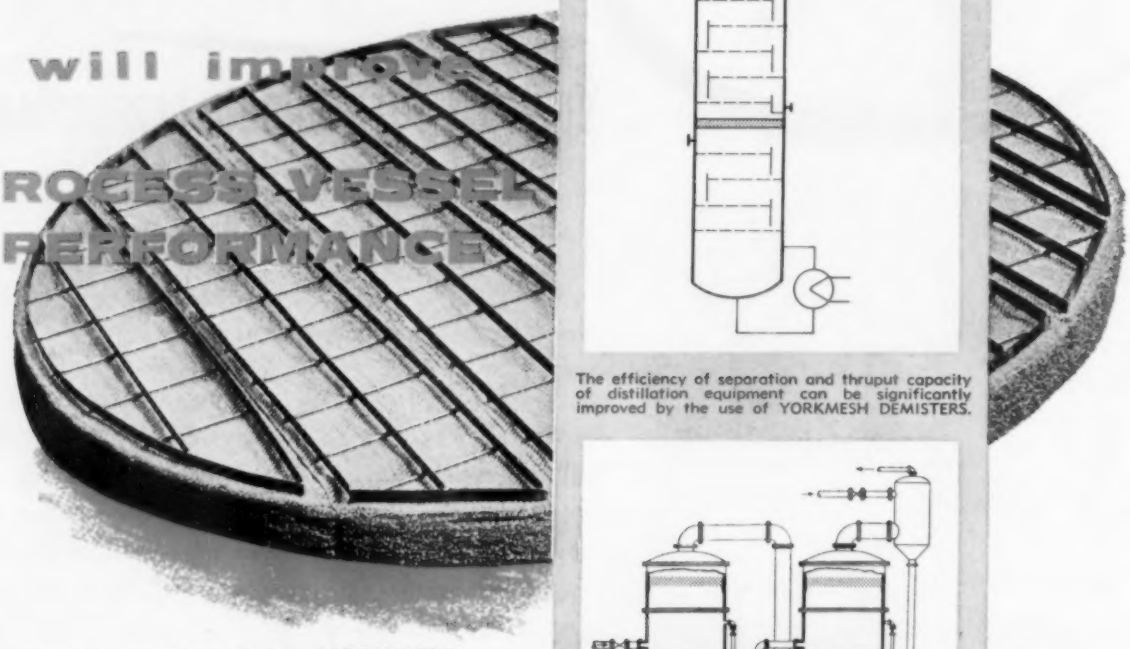
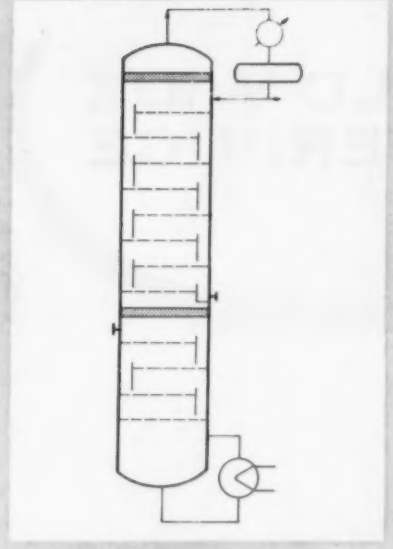
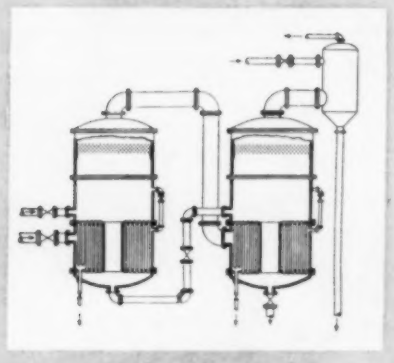
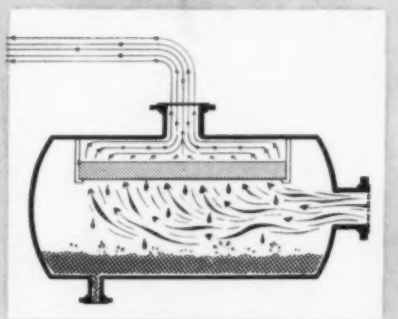




The efficiency of separation and thruput capacity of distillation equipment can be significantly improved by the use of YORKMESH DEMISTERS.



YORKMESH DEMISTERS installed in evaporators avoid product loss and provide clean condensate.



YORKMESH DEMISTERS installed in Knock-Out Drums result in high separation efficiency at low pressure drop.

It will pay you to investigate YORKMESH DEMISTERS if your process vessels need a lift in efficiency. The versatile knitted wire-mesh pads are being used more and more throughout industry to ***stop*** liquid entrainment and improve the performance of:

Vacuum Towers, Distillation Equipment, Gas Absorbers, Scrubbers, Evaporators, Knock-Out Drums, Steam Drums and many others.

Here is what happens when YORKMESH DEMISTERS are installed:

1. As vapor disengages from liquid it carries with it fine liquid droplets.
2. When the vapor stream passes thru the fine wire mesh, the liquid droplets impringe on the wire surfaces, coalesce in to large drops, and fall.
3. The vapor is now dry and free from entrained liquid.

Send us details on your type of process vessel or operation, vapor flow rate, pressure, temperature, and density or molecular weight; approximate amount of entrained liquid, viscosity, and specific gravity . . . for existing equipment advise dimensions, indicate vertcial or horizontal vessel and material of construction required for mesh and grids. Complete details will make it possible for us to present our recommendations and quotation.

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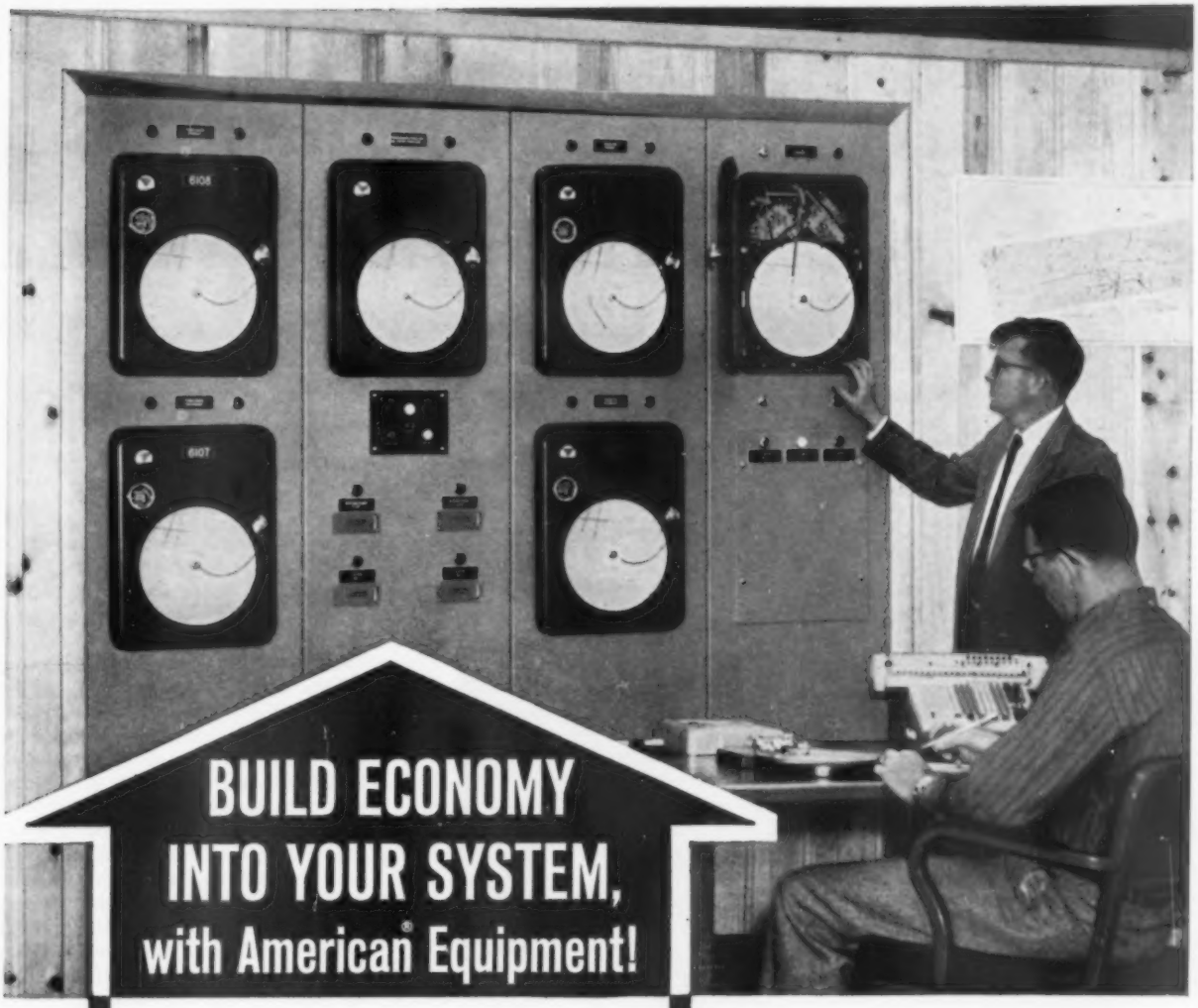

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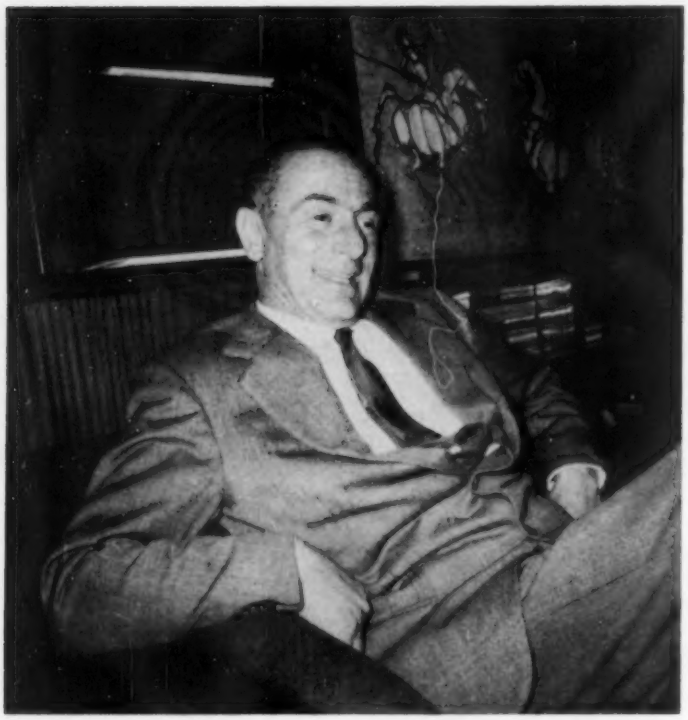
AN INTERVIEW

# THE BRISTLING BATTLE

By ERNESTINE ADAMS

**The head of Italian State-owned ENI is an ambitious man but you can only guess at his goal . . . Right now he expands his company with one hand and uses the other as a fist to shake at international oil companies . . .**



*A moment of relaxation for the ruler of ENI. He works 12 to 14 hours a day — takes no salary.*

MENTION "MATTEI" in oil circles and every eye looks to Rome. There is a running feud between the president of Ente Nazionale Idrocarburi, Ing. Enrico Mattei, and a group of international oil companies. The final battle may never be fought but casualties on both sides are more than pinpricks. And don't get the idea that it's a mouse attacking the lion.

Mattei holds securely the reins of a vast state-owned complex that includes most operations in the petroleum industry and its supplies and services. He is one of the chief power centers in Italy—popular with the public, a magnet to his top quality staff who say "our president" in almost reverent tones.

He has plenty of weapons and no hesitation about using them. He didn't hesitate to break the respected 50-50 formula for splits of oil profit when he got his first concession in the Middle East. In spite of concessions from Arab countries, he buys some oil from Russia at prices that hurt Middle East markets. He reduced oil products prices in Italy and holds the threat of cut prices in more of Europe. His enemies say that high prices for natural gas make up for profitless oil.

One of Mattei's attractions is the Horatio Alger-type story of his rise to fame and fortune—only it was the other way round, first—fortune. He was born April 29, 1906 in Acqualagna, province of Pesaro, in the Marche region. His father was a noncommissioned officer of the Carabinieri (a militarized national police) who was noted for brave deeds but not strong on economic gains. At 14, young Enrico began working in a factory that made beds at Matelica where the family had moved. He went from factory hand to management in quick time, getting an accounting diploma in the process, then quit to become Milan's representative of a German chemical firm. This led to an enterprise of his own, making chemicals for the tanning industry, which began the fortune he depends on today.

When war came Mattei was made chief of Christian Democrat underground forces in northern Italy. This was a harrowing period that plowed a deep row between the principled and unprincipled. Said one of the fighters of those days, "The times were a shadows. Honest people stole. Patriots turned traitors. Mattei was a hero. He disdained personal profit and planned and fought courageously. In a time when dishonor mired some of our big men, never a breath of scandal touched him."

Mattei still has the aura of asceticism that must have cemented his following in those troubled days.

Twice he was captured by the Fascists and both times he escaped. He had never had military training but he organized a group of 82,000 partisans so successfully that he was decorated

# OF MATTEI

*In his speeches he piles the woes of the industry on the handy backs of international oil companies.*

by General Mark W. Clark for "heroic activity."

He was a member of the Christian Democratic party executive committee for Northern Italy when war ended. Then he was elected a deputy to the first Parliament.

In 1945, appointed northern commissioner of Azienda Generale Italiana Petroli (Mussolini established the agency to search for oil and gas), Mattei went north and looked over what he had. His orders were to liquidate all holdings. In spite of the fact that there was already a buyer in the offing, Mattei decided to drill southeast of Milano.

One of my first questions when I interviewed Ing. Mattei was, "What made you decide to take a chance on drilling?".

"I'm an industrialist (we would say enterpriser) and I thought it was too early to give up. It was a great risk but I felt I had to take a chance. Italy was poverty-stricken after the war and we needed energy so much."

"How many wells did you drill before you discovered gas?"

"We drilled only one and that was difficult enough. I went all over the area and talked to all the geologists and finally selected the spot to drill. We drilled that one well and it was a producer."

This well brought in the biggest field that had yet been found. The new commissioner was "shot with luck." The excitement of discovery — and who hasn't felt its pull? — put Mattei in charge of AGIP and left him to his enterprising. To some degree postwar uncertainties gave him a free rein — anyone who succeeded was pressed on. AGIP was poured into what became in 1953 ENI, and Mattei built the group up as if each day were the deadline.

Now ENI spreads over Italy, a gigantic complex with five main divisions: AGIP Mineraria, exploration, drilling, and production of oil and gas; SNAM, pipeline, tankers, and other transportation; AGIP, distribution; ANIC, petrochemicals and refining, and AGIP Nucleare, atomic energy.

Under these come a large number of subsidiaries. Among the most important are: SAIPEM, specializing in construction and erection of industrial plants and pipelines and also acting as drilling contractors; SNAM Progetti, which handles the design for this work; and NUOVO PIGNONE, which manufactures oil industry equipment from complete refineries to drilling rigs and floating platforms for offshore drilling (worth $5 million dollars) as well as pre-fabricates service stations.

Northern Italy is spotted with the six-legged dog with a flaming tongue. It is the sign of the 4000 AGIP service stations. Said an AGIP employee, "The dog is man's friend. With six legs he goes faster." The company has a number of modern chalet-type motels and continues to build more.

But ENI's major earnings — some $100 million — still come from the production and distribution of natural gas in the Po valley. ANIC at Ravenna, one of Europe's largest petrochemical plants, uses natural gas from nearby fields. Another petrochemical plant is being built in Sicily and one is planned for Southern Italy where gas was discovered in 1959.

If any comprehensive marketing study goes into this growth, I could not find out about it. Mattei follows the direct action course. He goes into sales when he has something to sell.

Relentless competition is carried on between international companies and ENI for Italian oil products markets. Price-cutting has pretty well wiped out profits. Montecatini, a private Italian firm, provides stiff competition in petrochemicals.

There is no question that the ENI president is a superb politician. He has the qualifications. Lean and handsome, he exerts strong personal magnetism. As a speaker he commands attention — both for content and for delivery. The speeches are well written, rank high whether you agree with the content or not. At every opportunity he piles all the woes of the industry on the handy backs of international oil companies. "Do you write your own speeches?" I asked.

"Not entirely any more. The staff supplies all the data and I edit it to fit my style."

Mattei must be nimble to pursue mushroom expansion and keep all channels operating — from acquiring crude, which ENI needs, to selling fertilizer, which has a limited market in Italy.

This has led him into some deals that are, to put it mildly, frowned on by the private international oil industry.

It has been said that Mattei reacted bitterly when ENI was left out of the Iranian consortium and the result of this peeve was his later agreement with

the Shah of Iran which altered the traditional terms of oil concessions.

Three concessions (about 8800 sq miles) were granted to a company formed on a 50-50 basis by one of the ENI Group companies and the National Iranian Oil Company. Fifty percent of net profits are assigned to the Iranian state, as royalties and taxes, the remaining 50% being divided between the two parties so that Iran gets an overall amount of 75% of total profits. Morocco later granted exploration rights over 10,000 square miles on the same basis.

"What about operations in Iran and Morocco," I asked. "I've heard rumors you had found oil in both places."

"It's too early to be definite in Morocco," said the ENI president. "We have only drilled 2900 meters in one well and are beginning another. I can say that we are most encouraged. In Iran we have found oil in large quantities. Our discovery well produces 3500 b/d of 31 deg API gravity. We are building a pipeline and in 1961 expect to average 6000 b/d. We estimate 16,000 b/d in 1962 and 50,000 b/d by 1963."

ENI's biggest production abroad is in Egypt. From 1956 on, a combine of ENI and the Egyptian state has been exploiting the oil reserves in the Sinai Peninsula. Mattei has also reached concession agreements with Tunisia, Libya, the Sudan and Somalia.

Largest Italian production for ENI is at Gela in Sicily where AGIP Mineraria engineers have performed quite a feat in producing 7-8 deg API gravity oil — too heavy to flow. This oil will be treated in a large petrochemicals center for the production of petroleum products, fertilizers and plastics. I commented that the Gela project was a triumph of technology.

"You are the first American to say that," said Ing. Mattei but he smiled pleasantly, which balanced the rancor in the words.

*"We are developing many executives to take over management."*

When I saw the ENI president in October he had just signed the agreement with Russia for 12 million tons of crude oil over a 5-year period. This figures out at 48,000 b/d on an even day-to-day basis.

"In the Soviet contract, what price are you paying for crude and what price is Russia paying for your synthetic rubber and pipeline equipment?" I asked.

"This would be hard to put into figures since it's all an exchange deal. You can estimate that the total value of the deal is $200 million," replied Mattei.

"Could you give me an idea of what amount or what percentage you will make as a profit on the exchange?"

"Not exactly. We certainly expect to profit. I am all for profit. This is a contract between a producing country and consuming country with no middlemen. In the Middle East it is 40% royalty, 40% profit to the companies and 20% cost of production. Russia is not obliged to leave part of the profits in the hands of private international companies and can therefore offer advantageous prices to the purchaser."

"Do you feel safe in depending more and more on Soviet oil supply?" (This is a question every West European purchaser of Russian oil is asked.)

"Apart from the fact that the oil imported by us from the USSR only covers a small proportion of our consumption, the increasing number of sources of supply makes this sort of worry quite unfounded. Italy is a heavy consumer country and it is right to buy crude oil wherever prices are cheapest. If other producers are bothered about this they have the remedy in their own hands — lower their prices. On the other hand we ourselves produce oil and shall produce a lot more in the next few years so that our country will be sufficiently guaranteed against any interruption of supplies from some of our sources."

It should be noted that Italian inland consumption jumped 13% in 1959 over 1958 to 293,000 b/d and the increase in 1960 is estimated at 22% above 1959. This kind of rise calls for drastic measures when production is only 36,000 b/d in the country, mostly in Sicily.

We went from there back to organization — "How far ahead do you do your planning?" I inquired.

*With Nasser: ENI's largest foreign production is in Egypt.*

"We have short-term, medium, and long-term programs — the last is only very general. We learned this planning from the Americans," he remarked.

"Well, we didn't learn it too long ago so you caught up pretty fast. What about investments?"

"In the next four years we expect to invest about $230 million per year in expansion of operations. This will be larger than ever before."

"Can you give me an idea how the expenditures will be divided. How much for exploration? How much for pipelines, etc.?"

"About 29% is earmarked for exploration, 7% for transport, 28.5% for refining and petroleum product distribution, 15% for petrochemicals and about 20% for the nuclear industry."

I had met a number of ENI's top executives and had been impressed with their high quality. I asked Ing. Mattei how he attracted and held men of such caliber when there is an admitted shortage of good executives throughout Europe. "Do you pay them more?" I added.

The ENI president answered this very seriously, "They believe as I do in what we are doing. Our fight in the oil world is a hard struggle and for that we must have the best men."

"The wide range of your political support indicate it's personal rather than ideological. Wouldn't ENI have rough going without you?"

"If you had asked me that four or five years ago it would have been an embarrassing question. Now we are in a better position. We are forming the character* of our group and gradually our people are coming in contact with government people and we are developing many executives who can take over the management. We are now in a much better position and I feel more confident about the future."

In the spring of 1958, Booz, Allen and Hamilton, management consultants, set up a new organization plan for decentralizing ENI. At San Donato Milanese, a model ENI town, where operational headquarters are established, there are schools for everybody — from executives to service station men. In administrative office in Rome, one of the consulting firm's men joined ENI and heads its Tecnica Direzionale today. The ENI group is well organized now to satisfy a craving for knowledge and to offer opportunity when a man acquires it.

And what is this man like who has built himself a business empire without material reward? What makes him work 12 to 14 hours a day? What does he want?

*Image in our advertising lingo.

Mattei has always refused a salary and part of the expense account allotted him. The latter goes to an orphanage. He has no children. He and his Austrian-born wife, whom he married in 1936, live in a modest apartment in Hotel Eden in Rome.

Of his family still living there are a brother in Matelica; a brother who manages Enrico Mattei's business in Milan; a married sister, and a younger sister whom I met. Miss Mattei manages the roof garden at the top of the main office building at San Donato Milanese. Her aristocratic bearing and poise are similar to her famous brother's.

Apparently his own needs and any family demands are easily met by his private income. In that situation the reason for his whole-hearted immersion in business is not easy to determine. And even here his personal wants are limited. His office, though in excellent taste, is not luxurious by any measure.

Here may be one answer: Behind his desk is a row of whitebound books with only dates in gold on the back. When I asked about them, Ing. Mattei brought some to the table where we sat. They are a collection of the derogatory articles, critical news items, and stinging cartoons that had been published about the ENI president since 1949.

"I've proved the older accusations were wrong," he said, "but the volumes grow thicker."

Perhaps his aim is to refute all skepticism.

But there is another view that may come closer. Mattei is an anachronism in the oil industry. He has the delight in the industry of a Mike Benedum and the canny determination of a John Rockefeller. He would have fitted like a fencer into the clamor and battle of early days. He battles to build an Italian oil company that will be counted among the big ones on the international scene. He fights international oil companies in order to become one.

*"Fishing is my business — oil is my real hobby."*

"I understand fishing is your only hobby. Do you have any others?" I asked and fell into a trap.

"Fishing is my business — oil is my real hobby, my recreation," he insisted. "I've been to Alaska three times and each time I've caught enough salmon to pay for my trip."

"You mean you sell the salmon you catch and that pays your expenses?"

"Certainly."

Maybe that explains Mattei's success — perhaps only a hobby can bring out the sort of carefree skill that champions have. ★ ★ ★

# LESSONS OF THE OIL GLUT

HELMUT J. FRANK

ONLY A FEW YEARS ago most experts held that the United States would soon be unable to produce enough oil for its domestic needs. Today our oil wells could produce over 25% more than they do. The question used to be asked, "Are we running out of oil?" Now it is, "How can we stem the flood of unwanted oil?"

This change has been sudden and drastic. Why did it occur? How great is the United States surplus, and how serious is its impact? Can we reasonably expect conditions to improve in time, or will we need to make basic changes in producing practices and governmental policies toward the oil industry?

The oil surplus does not exist in the United States alone. In other parts of the world, notably in Venezuela and the Middle East, the productive capacity of oil fields is well above current demand. Just as these countries find control of productive capacity increasingly difficult, so the United States is discovering that its problem is very hard to solve. This is in spite of our isolation from the world market since mandatory import controls were enacted early in 1959.

Petroleum, with an average long-term rate of expansion of about six per cent per year, has traditionally been an outstanding growth industry. In recession years the increase of consumption slowed down—the sales volume hardly ever decreased—but this was always made up by accelerated advances during the next upswing. This strong upward momentum carried through the first postwar decade. But during the past four years, demand has grown by an average of only about 2.5% a year. Moreover, there is strong evidence that the industry has entered a new phase, during which its expansion will be far less rapid than before.

### Manifest improbability

In part, this more modest rate of growth mirrors a smaller increase in total energy consumption in the United States. Even more significantly, the very high growth rate achieved by the petroleum industry previously had been due to the inroads which oil and gas were making on coal, wood and other fuels. Up until 1956 oil and gas consumption was expanding twice as fast as total energy consumption. Had this trend continued, oil and gas would have taken over the entire energy market by 1970—a manifst improbability in view of the special advantages which coal and hydroelectric power possess in specific uses and locations.

Since 1956 oil and gas consumption has continued to outpace the growth of other fuels, and their combined share has grown to nearly three-quarters of the total energy market. But most of this recent increase has been of gas rather than oil. Thus, the growth of fuel oil sales, which make up over two-fifths of total oil consumption, has slowed down enormously, while gas sales continue to expand rapidly; some analysts even predict actual decreases in the use of oil by the vast space-heating market. In thermal power plants, which represent the most rapidly growing energy sector, the prospects for oil are even bleaker, particularly since natural gas is being sold as boiler fuel at very low prices.

Even in the case of motor vehicles, where other fuels cannot be readily substituted for oil, the chances of achieving a high growth rate are slim. The average compact car gets 50% more mileage from a gallon of gasoline than the average standard make. The only petroleum products currently registering healthy growth rates are jet fuels and other "minor products" such as asphalt and road oil—used chiefly in highway construction.

### Rigid price ceiling

Slower expansion of final demand is only one of the elements contributing to the oil surplus. Another factor cutting into the demand for crude oil has been the sharp reduction, in recent years, of the output of heavy (or "residual") fuel oil by refiners. Under normal conditions, heavy fuel cannot be sold above the comparable price of coal, with which it competes intensely in a number of uses.

But coal prices, under the impact of an extensive program of rationalization and modernization, have not increased during the past decade. This imposes a rigid price ceiling on heavy fuel oil. In fact, this product sells typically for less than the price of domestic crude. Heavy fuel oil can be produced economically only from low-gravity, low-value crudes, such as those in the Caribbean; but this results in a displacement of domestic by foreign oil. This tendency has not been ended by the mandatory import controls, since imports are allowed where there is a gap between demand and domestic production.

Finally, the rapid growth of natural gas production has been accompanied by an almost equally high growth rate of natural gas liquids—by-products of natural gas. New refining processes have been developed to upgrade these by-products into high-octane gasolines, thus again displacing large quantities of crude. Together, these influences have apparently changed oil from a "growth" to a "slow growth" industry.

During the Korean war, the federal government became concerned over the industry's ability to meet emergency

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demands in an international crisis. Government petroleum experts recommended that a surplus capacity of one million barrels per day—then about 15 per cent above actual production— be developed and maintained as insurance against any emergency. By mid-1954, however, this surplus had reached not one, but nearly two million barrels a day; and since 1958 it has ranged between 2.7 million and three million barrels per day.

Slower increases in the demand for energy and inroads of natural gas and gas liquids have by no means been the sole factors responsible for the surplus.

Recent events make it clear that the industry has raised its crude producing capacity far above current requirements, including a safety factor for emergencies. Why should this have continued well into a period of sharp production cut-backs, weakening prices and declining earnings?

One reason is largely technical. The prime attention of management, as well as officials responsible for national policy, traditionally has been focused not on productive capacity but on "proved reserves." Estimates of such reserves, which are compiled annually by the American Petroleum Institute, are so conservative that some top oilmen now consider them practically worthless. The API estimate of "proved reserves"—reserves that are economically recoverable—at the end of 1959 was 31.7 billion barrels. A more liberal estimate of proved reserves raises the figure to 45.8 billion barrels.

### Recoverable reserves

If one adds to this, as does the Secondary Recovery Committee of the Interstate Oil Compact Commission, amounts recoverable from present fields by processes known to be physically workable but not yet tested commercially, total recoverable reserves become 89.8 billion barrels, nearly three times the API figure. One suspects strongly that, because it focused for many years exclusively on "API reserves," the industry drilled many more wells than were required to assure its resource reserves during the foreseeable future.

An even stronger factor in producing excess capacity has been the emphasis placed on development drilling. The number of development wells exceeded 40,000 per year during the mid-1950's; since then it has fallen only very slightly—except in 1958, a recession year. By contrast, exploratory wells, which are drilled to discover and define new fields rather than to expand immediate productive capacity, have fallen from a peak of more than 16,000 in 1956 to about 13,000 a year.


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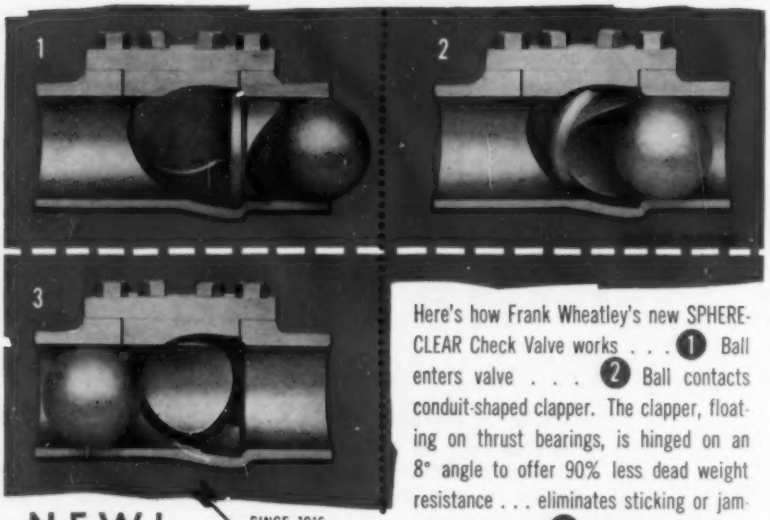


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The chief blame for this lopsided emphasis must go to the leading producing states for the manner in which they have been handling prorationing —production quotas. Production quotas are typically set with regard to number, or, at best, number and depth of wells. No allowance is made for the area a well can adequately drain without violating sound conservation practices.

### Vicious circle

The result is a vicious circle: operators will find it worthwhile to drill additional development wells, even though fewer wells would perfectly suffice. This is because a larger number of wells gives them a larger production quota, and thus they get a faster return on their investment. The state authorities then have to reduce allowables—quotas—further in order to spread the available market among the greater number of wells. And this, in turn, augments the pressure for still narrower spacing of wells.

Excessive development drilling is by no means the only source of the oil industry's difficulties. Another is the failure of the price mechanism to function effectively at the crude oil level. Crude prices are clearly administered, rather than determined by the market, and have shown a marked upward tendency in recent years. In part, this reflects the fact that an exhaustible natural resource will eventually become more expensive to produce, though this tendency is slowed by improvements in the techniques of finding and producing oil.

In addition, inflation is still exercising a strong impact on crude oil costs; the industry is gradually using up reserves discovered before World War II, when prices were far lower, and replacing them with reserves developed in recent years. Finally, unit costs have risen sharply in the last few years, because as production is cut back, overhead costs (which constitute the major share of total costs) are spread over fewer and fewer barrels of production.

These tendencies toward increased prices have been powerfully reinforced by governmental policies on both the federal and state levels. Federal policy, through the depletion allowance and other tax benefits, permits higher profits to be earned in the production phases of petroleum and other mineral industries, and thus tends to attract additional capital into them. Any long-term tendencies toward increasing real costs should be slowed down by this flow of capital which should increase efficiency. There are, however, offsetting factors which tend to increase prices.

For one thing, the depletion allowance is based on the gross value of production (subject to a limit of 50% of net income), so that higher wellhead prices mean a higher depletion allowance. For another, vertically integrated firms are able to benefit from higher crude prices, even if the price of finished products does not rise equivalently. According to a study by Professors de Chazeau and Kahn of Cornell University, an integrated oil company that produces 38.5% of its crude requirements will gain from higher crude prices even if only 50% of the increase is passed on; if it produces 77% of its crude, it will benefit even if product prices remain entirely unchanged.

### Prorate output to demand

An even more pervasive influence on crude prices is the form of conservation policy practiced by most leading producing states. In addition to setting purely physical limits on production, clearly designed to prevent wasteful use of natural resources, they prorate output in line with the market demand for their crude oil.

Two assumptions appear to underlie this policy. First, demand for petroleum products is held to be virtually inelastic—sales would not expand significantly if prices were allowed to fall. Second, this policy seems to rely entirely on a physical, rather than economic, concept of conservation—that is, prices should be high enough to cover operating expenses of inefficient wells, regardless of whether the additional reserves thus made available are actually required, and regardless of the cost involved. If, as a result, potential production exceeds market demand (at prevailing prices), it is not the marginal wells—the least efficient—which are forced to shut down, but the most productive ones.

### Shored-up prices

The operation of these policies was strikingly revealed on the two occasions when crude oil prices were last raised. In the summer of 1953 prices were advanced, although the strong demand forces active during the Korean boom had already begun to weaken and product prices had begun to decline. Again, early in 1957, during the Suez crisis, crude prices were raised although refined products were in heavy surplus. In both instances the state authorities shored up crude oil prices subsequently by ordering deep production cutbacks. In Texas the number of producing days for prorated wells fell to 123 in 1959; they may not exceed 105 in 1960.

Two major conclusions emerge. First, there is no automatic mechanism capable of adjusting crude supplies to requirements. In fact, it is doubtful whether the flow of investment funds

*YOU CAN'T EAT STATISTICS AND HAVE THEM, TOO.*

The editorial on Page A-6 voicing our concern about unreliable economic guideposts was written before we read this article emphasizing the shortcomings of statistics and their effect on industry activities

"Lessons of the Oil Glut" was published in the January issue of *Challenge*, published by Institute of Economics Affairs, New York University, under the title, "A Lesson in Excess Capacity" and we are reprinting with permission of the editor, Haig Babian.

The author, Helmut J. Frank, is a Resources for the Future Fellow at Columbia University. Frank views the situation from the same angle as Bruce C. Netschert, a staff member of Resources for the Future. In 1958 the latter took the position that oil and gas supplies were ample through 1975. His "The Future Supply of Oil and Gas" warned that the U. S. was not faced with urgent need to develop atomic energy and that the coal industry could not expect to gain from petroleum scarcity.

This position rests on a number of variables. Netschert rightly considers technology a dynamic factor in supply availability.

Petroleum industry statistics are difficult to handle and areas of agreement are limited. Some years ago for instance, political liberals were shouting that we were running out of oil, that petroleum resources should be protected by the government and more oil shipped in. Statistics are colored by causes. To shape our industry's future we need some black and white data that shows up clearly.

*THE EDITOR*

into oil responds promptly and adequately to changing capital needs, in view of the industry's unusually heavy reliance on internal financing. Second public policy, through tax provisions, market demand prorationing and, recently, mandatory import controls, has greatly enhanced the attractiveness of producing operations, thus increasing the flow of capital into the industry. What are the implications for the future?

The most striking aspect of the current situation is that we are in the dark as to the actual amount of oil in the earth and the probable growth of future requirements. Oil geologists are unable to tell us how much oil we have. Changes in technology and demand prevent economists from accurately forecasting future needs. It is therefore impossible to judge definitely whether the surplus is limited to current productive capacity, with reserves only barely adequate for future needs, or whether the reserves are more than adequate.

### Facts lacking

Moreover, we do not, so far, have the facts needed for determining the likely oil requirements in a future (as distinct from a past) emergency, or for judging the importance of maintaining a high degree of national self-sufficiency in oil, the cost of doing so, and the best manner of allocating the burden. Until we have reliable answers to all these questions, no sound basis exists for evaluating current policies.

We may find, upon careful, objective examination, that the current surplus is likely to be absorbed during the next few years as demand expands. In that case, the principal policy change needed would be a modification of prorationing practices that would remove the incentive toward excessive development drilling. The total flow of capital into producing operations should not be discouraged under such conditions.

On the other hand, we may find that recoverable reserves, as a result of technological progress, have become more than ample for our future needs. If that is so, present incentives to invest in oil production may have to be reviewed to determine whether they have attracted excessive resources into the industry. In that case, also, it might be desirable to consider modifications in current conservation practices—modifications aimed at strengthening the price mechanism so that changing market forces could influence conditions in crude production more effectively than at present. ★ ☆ ★


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**HOW TO BE A MANAGER**

# Identify Your Shortcomings

John D. Quinton

*"We see things not as they are, but as we are."* — Kant

BEFORE WE CONSIDER the subject matter of this article we will have to make two assumptions:

1. You *want* to go up the next step to a higher position, and
2. You are willing to pay the price of changing yourself.

The second assumption is necessary because no one can move a step up by remaining the same person. The next step up, by definition, calls for increased abilities, new approaches, new learning and new traits.

The most difficult factor involved in identifying one's shortcomings is in the recognition that facts banish fears and fantasies and therefore a psychological assay of oneself is necessary. For change comes about as a result of self-analysis.

Self-analysis is possible only when the aspirant realizes that the goal of a higher position must be considered in terms of his abilities and personality. Therefore, he is not afraid of what self-analysis will reveal and eagerly searches for ways of evaluating himself so any shortcomings can be detected and cured. This may sound optimistic but, with everything else being equal, shortcomings *can* be identified and overcome *if the person wants to change.*

And that is the key to self-analysis: *The person must want to bring about the change.* No one else can do it for him. Therefore, it is futile and tragically unrealistic for him to attempt this self-analysis unless he sincerely wants to change.

Throughout industry when we talk of someone moving into a higher position we talk of the "problems" of the job. We assume we must face these problems and resolve them. A moment of reflection might reveal that the next position does not involve any "problems" at all. The present successful occupant of that job seems to be coping with the "problems."

JOHN D. QUINTON, *training representative, Tennessee Gas Transmission Company has had a number of articles published in magazines. He became associated with Tennessee Gas a year ago and before that was training representative for Shell Pipeline Company for four and one-half years.*

QUINTON *received his B.A. degree from Lincoln Memorial University, his M.A. from Tulsa University and has spent two years on his Ph.D. at Kansas University. After leaving school he was professor of psychology at Kansas University and at Tulsa University, then for two years head of the psychology department at Arkansas Polytechnic College. He left the educational field to become consultant for Douglas Aircraft and Service Pipe Line Company in Tulsa.*

Armed with self-analysis on the back of facts you can defeat fears.

## ATTITUDE TOWARD JOB

No — the problems do not reside in the position but in the aspirant's attitude toward the job. The problem situations the individual will face in the new job are, generally, of his own creation. He has, by assembling bits of reality into distorted beliefs, manufactured obstacles in the next job. Thus, many of the problems and fears attributed to the next job do not lie in the job itself but are "created" by the man's attitude and beliefs about the position.

In identifying any shortcomings he might have, the realistic approach for a man to take is to lay out a *plan* for detecting his weaknesses. And remember — there is a difference between planning and worrying. Planning is constructive — worrying is a destructive form of self-pity.

In planning, the problems are approached singly and with calm. Concentration is on the solution of the problem and not on frightening thoughts of what will happen if the plans go wrong. After a person has done his best calmly and intelligently and things go wrong because of unforeseeable events then there is no reason for guilt or "crying over spilled milk."

On the other hand, worry brings on upsetting emotions. This leads to disorganized and ineffective behavior. Should this emotional behavior continue for a prolonged period the result is fatigue, nervousness and irritability. And, incidentally, this is not a good advertisement for a promotion to a higher position.

There is no victory for the worrier until he attacks his problems one at a time.

## WHAT ARE YOUR SHORTCOMINGS?

When searching for his shortcomings it is wise for a man to keep in mind that he must *accept himself as he is*. Not what he thinks he is or what someone else wants him to be. Most of the difficulty arising from self-analysis comes from our stubborn refusal to accept ourselves as we are. We will consider this later when we discuss self-deception.

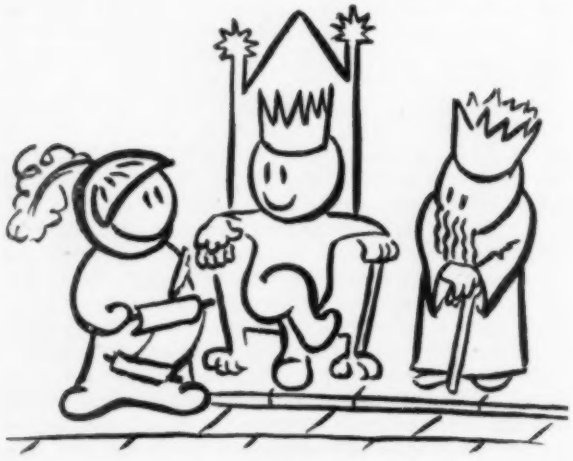
We have been talking about the necessity of self-analysis in identifying shortcomings. Now let's get down to fundamentals. What sort of shortcomings should a man look for in himself? Well, first, the man should get some insight into the requirements of the position he is shooting for. How else can we determine our shortcomings if we don't know what will be required of us?

There are several ways of going about this. Get a job description of the position. Talk to the present occupant and get his viewpoint and recommendations. Talk to someone that once occupied the position and has moved on up the ladder. Once the requirements, both emotional and intellectual, have been determined then the self-analysis can begin.

Of the above mentioned requirements, emotional and intellectual, pay close attention to the emotional because it is less likely to be remedied. This includes all the traits of personality that make for success or failure through their effect on other people. For a manager commonly spends the bulk of his time handling people.

## CHECK LIST OF REQUIREMENTS

The first step then in identifying your shortcomings for the next position is to take under analysis the functions of a manager's job and the human relations requirements of any managerial position. Briefly, let's consider a check list that will help the analysis.



Talk to present occupant and to his predecessor.

**I. Functions of a Manager's Job**

- **a. Forecasting**—forming judgments of the factors that will influence the completion of a task.
- **b. Planning**—determining the things that need to be done and the methods for doing them.
- **c. Organizing**—setting up manpower and facilities for doing a specific job.
- **d. Directing**—the continuous task of making contacts with subordinates; training, assigning; giving orders.
- **e. Coordinating**—scheduling and directing efforts of individuals and groups.
- **f. Controlling**—seeing that work is done according to plan, evaluating results, and checking costs and quality.

**II. Human Relations**

- a. Let each man know, periodically, where he stands.
- b. Give credit when due—commensurate with accomplishments.
- c. Inform personnel in advance of changes.
- d. Let personnel participate in plans and decisions affecting them.
- e. Gain employees' confidence, loyalty and trust.
- f. Know all personnel personally.
- g. Listen to ideas of subordinates.
- h. Do not push employees—suggest or request.
- i. Always explain why.
- j. When you make a mistake—admit it.
- k. Criticize constructively and in private
- l. Set a good example.
- m. Be consistent.
- n. Show confidence in your personnel.
- o. Set proper and realistic goals.
- p. Settle all grievances quickly.
- q. Back up your personnel.
- r. Be fair and firm.

In addition to checking yourself out on the above points, you must consider your other abilities and qualifications for the job. You may be an expert in Management and Human Relations and still lack specific knowledge for the next position.

## KNOW THE NEXT JOB

For instance, if the next job you have your eye on is supervisor of programmers in the data processing section

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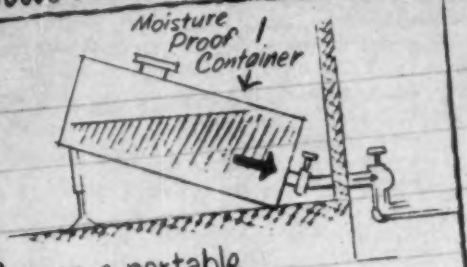


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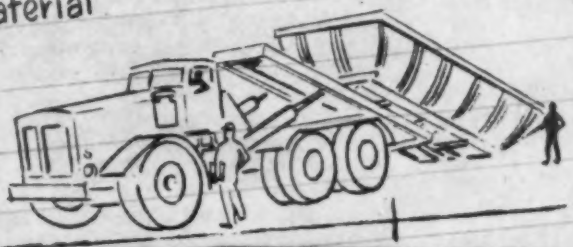

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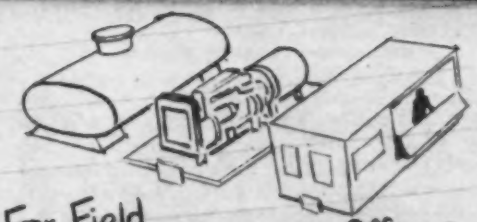

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and you have never had a course in data processing or programming then it becomes obvious what your shortcomings are.

The usual human approach to a situation such as this is to try to change the outside environment when the only genuine solution is to change the person himself. Characteristically, however, *the person exhausts his energy in attempts to change life and concrete situations because he is really trying to escape himself.*

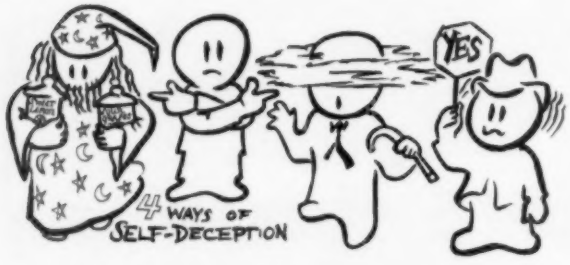
And here lies the pitfall of successful self-analysis. That is—self-deception. In fact, the many evasive attempts we undertake to escape the real "us" is ingenious.

## HOW YOU DECEIVE YOURSELF

Let's take a look at some of these self-deceptive pitfalls of self-analysis. These must be understood and eliminated from the self-analysis tool box or the person will never be able to see himself as he really is.

First is *rationalization.* This is the giving of false reasons for the real reason. Some wag has said that we "have two reasons for what we do; the reason we give and the real reason."

Rationalization can take many forms. There is the "sweet lemon" reaction. This philosophy is that "everything is for




**Rationalization, projection, foggy thinking, and conflicting conclusions.**

the best and there's nothing I can do." Then there is the "sour grapes" attitude. If the person can't attain the goal easily and doesn't want to put out the effort of overcoming his shortcomings he says "the job was no good anyway." This is the same as a person holding forth sometime on the unadvisability of owning an expensive car. It is too heavy, burns too much gas, too expensive to repair, no more comfortable than a small car. These are *his reasons.* The real reason is that he can't afford the large car.

The most familiar of rationalizations is the alibi. "Oh, the sun got in my eyes." "I would have gotten the new position but the boss has a grudge against me."

In self-analysis be true to yourself. Give the *real* reasons for the shortcomings.

Second is *projection.* This is the process of ascribing our shortcomings to other people or situations. We all do some projecting because it is painful to admit our deficiencies. But we cannot overcome our weaknesses by condemning others or the environment—we must analyze ourselves objectively and do something constructive about the shortcomings. Passing the buck helps the passer's ego but does not bring about an improved plan for self-improvement.

Third is *foggy thinking.* Clear thinking is absolutely necessary for self-analysis. The man that really wants to identify his shortcomings will look with a cold and unprejudiced eye and note any errors in his thinking.

Some examples of foggy thinking are: 1. Emotional prejudices and beliefs that will distort clear, objective reasoning. The tendency to read our own beliefs and prejudices into every analysis is very common. 2. Wanting to believe. People tend to believe what they want to be true regardless of the facts. We see the strengths in ourselves and believe the weaknesses to be stronger than they are. 3. All-or-nothing thinking. This is thinking in extremes. Everything is all black or all white. "I have no talent for that," is extreme. You may have *some* talent. In nature and people things usually come in degrees. Self-analysis should include the probability that we are not completely void of any ability, even though the little that we have may not be sufficient for the next position. 4. Not testing our decisions. One way to check ourselves on the decision we have made about a shortcoming is to lay it open to scrutiny. Test it on someone else. If the other person is truthful and open minded he will help you evaluate the decision.

Fourth is *conflicting conclusions.* This is very deceptive. We make a decision and then make a later statement that contradicts our earlier conclusion. An example: The writer was sitting in a barber shop in Arkansas the morning after a local man was arrested on a morals charge. One man made this statement: "That fellow broke every moral and written law in the book and has no respect for law or people. What we ought to do is go break him out of jail and skin him alive like the Indians used to do." See the contradiction? In one statement he is all for law, order and respect of the individual. In the next statement he advocates violently breaking the law and taking undue advantage of the individual.

In self-analysis this pitfall must be watched carefully.

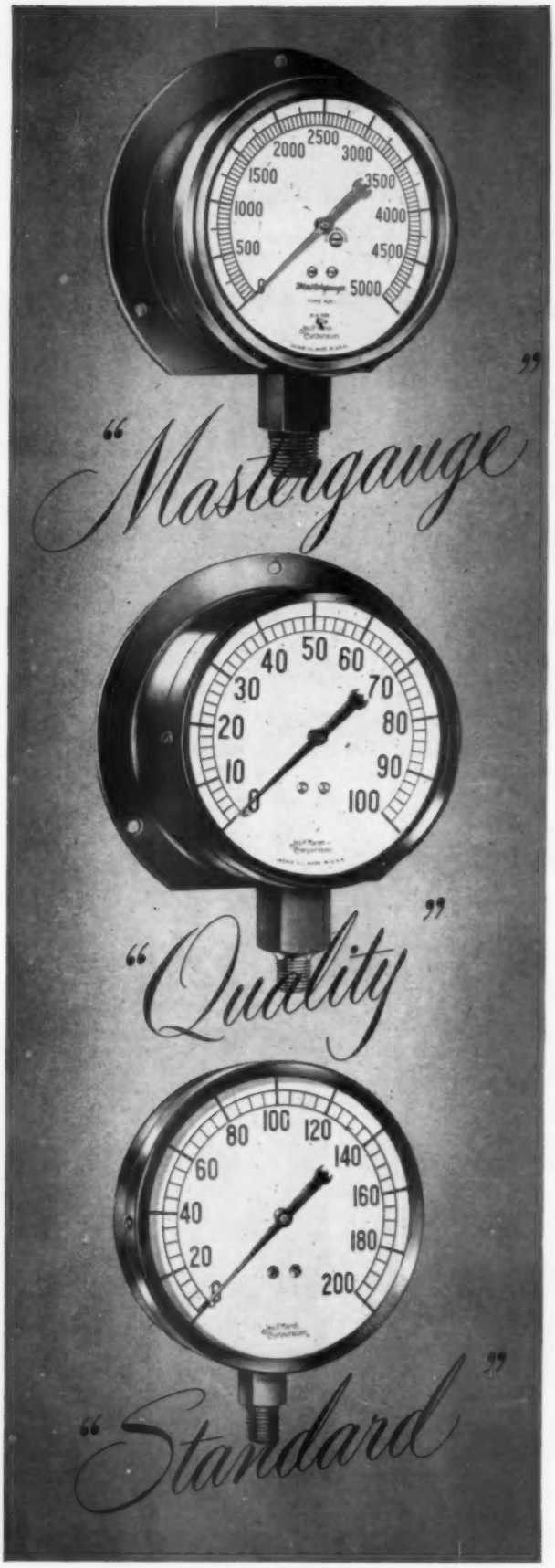
In summary it may be worth while to repeat the key to successful self-analysis. The fact that the individual must *want to change.* And this change can be brought about only if he accepts himself *as he is.* Such acceptance is capable of accomplishment . . . especially when the desire is strong enough.

### Think You Can Answer These?

1. What is the key to successful changing of oneself?
2. What are some of the pitfalls of self-analysis?
3. What are the functions of Management?
4. Name some of the essentials of good human relations.
5. Besides being adept at management and human relations what other shortcomings should we look for?
6. How do you ascertain the requirements of the next job?
7. Where do the "problems" of the next job arise?

### Read for Better Understanding

[1]*Braun, Carl F., "Management and Leadership," C. F. Braun and Company, Alhambra, California.*
[2]*Hepner, H. W., "Psychology Applied to Life and Work," Prentice-Hall, Inc., New York.*
[3]*National Association of Manufacturers, "Your Future Is What You Make It," 1947.*
[4]*Menninger, K., "Love and Hate," Horcourt-Brace, New York.*
[5]*Horney, K., "Our Inner Conflicts,"* Norton, New York.
[6]*Dunlap, K., "Personal Adjustment," McGraw-Hill, New York.*
[7]*Symonds, P., "The Dynamics of Human Adjustment," Appleton-Century, New York.*
[8]*Gardner, B. B., "Conserving and Developing Our Human Resources," Personnel Series, No. 127, AMA, New York.*
[9]*Hollingworth, H. L., "Judging Human Behavior," D. Appleton-Century, New York.*
[10]*Starch, Daniel, "How to Develop Your Executive Ability," Harper and Brothers, New York.*

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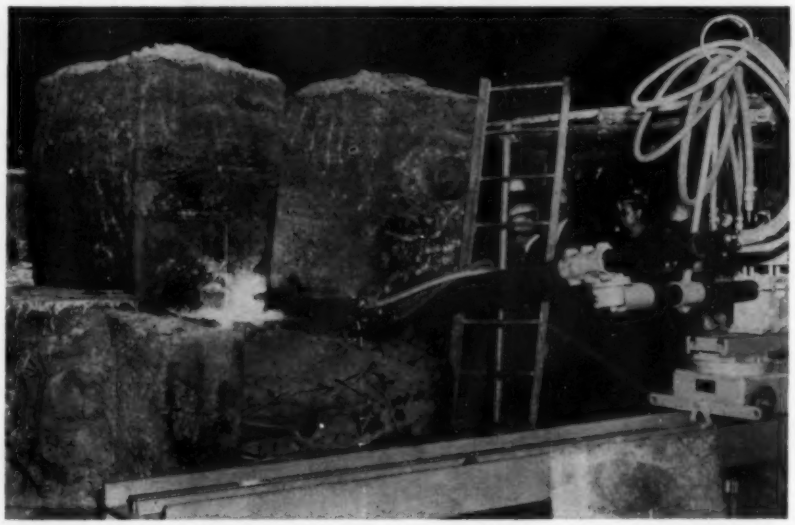
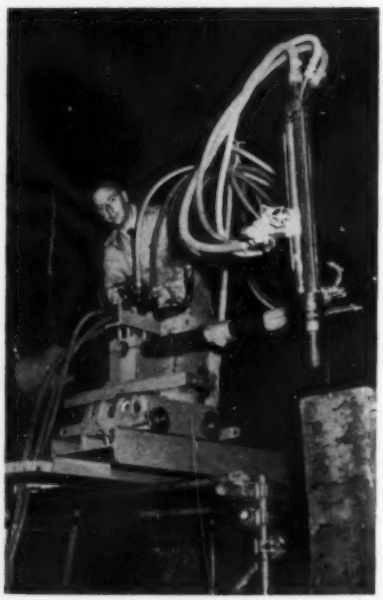
Propane has been used for cutting purposes for the past ten years, but until now equipment has not been available to take full advantage of the slow burning properties of this fuel. It is this slow burning property that permits the long flames necessary for deep cutting.

Propane is a gas extracted during refining of petroleum. Considerable work was done by Shell on exploring the application of propane as a fuel for cutting and the results of this work were made available to British Oxygen Gases. For deep cutting, British Oxygen developed specially designed nozzles which stabilize the flame and inhibit flashback. The demonstration in Germany was arranged by Deutsche Shell AG and took place in Osnabruck.



Here propane flame makes a horizontal cut through a steel casting 4 ft thick.

Propane gun is positioned to make vertical cut in steel. Deutsche Shell AG put on demonstration of effective new method.

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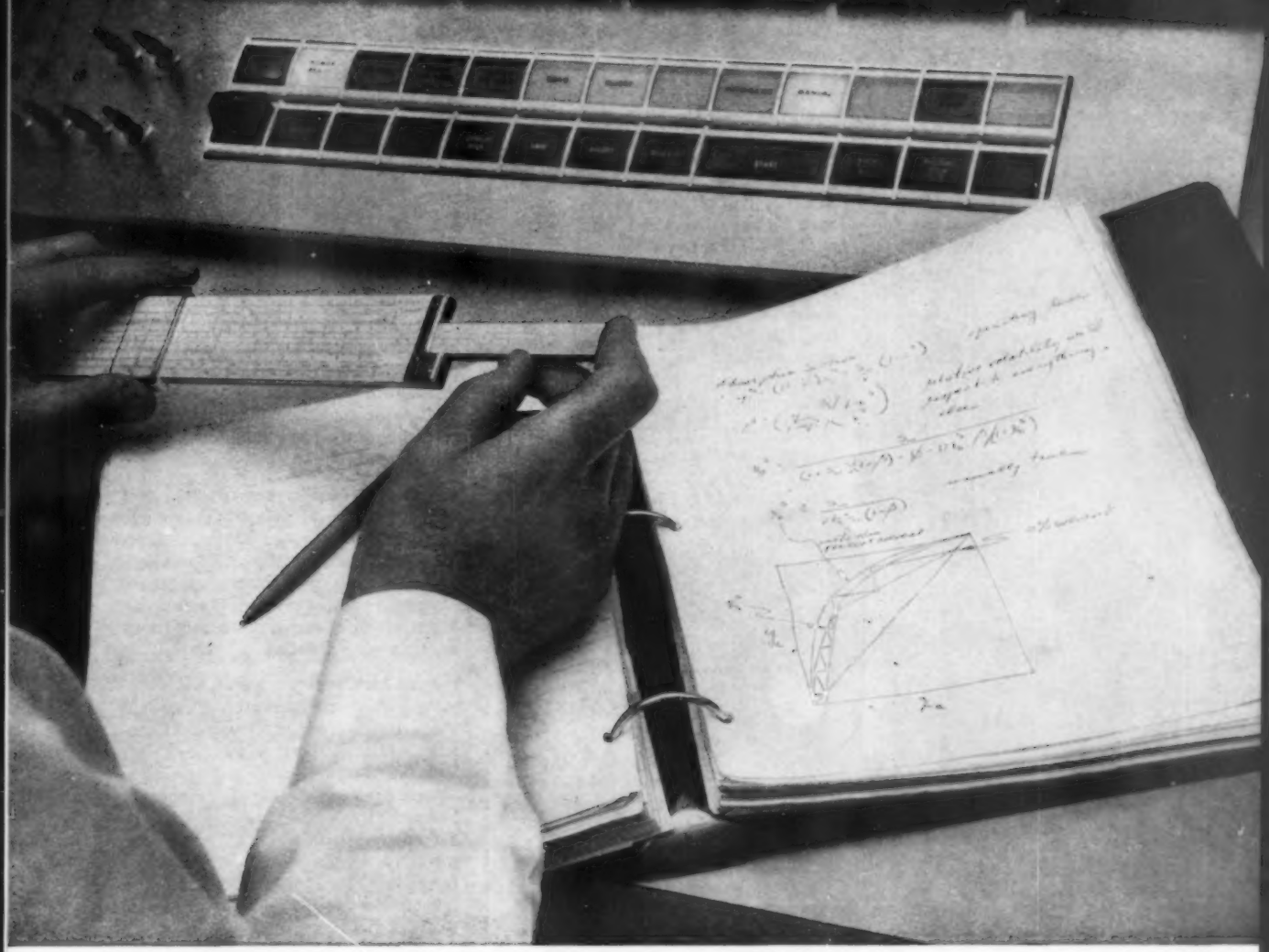

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The Unit Operations Simulator is available free of charge to all users of IBM 1620 Data Processing Systems. A basic 1620 rents for just $1,600 a month. Ask your local IBM representative to give you complete details on this versatile, low-cost engineering computer.

IBM's 1620 is a compact desk-size computer.

***Here's what the Unit Operations Simulator does for you: 1.** Computation of equilibrium constant. **2.** Computation of temperature from a given equilibrium constant. **3.** Computation of enthalpy of a vapor and/or liquid stream. **4.** Find equilibrium constant nearest unit. **5.** Computation of temperature from a given enthalpy of a vapor and/or liquid stream. **6.** Bubble point and dew point calculations. **7.** Split one stream into two at specified ratio. **8.** Mix two streams of same phase. **9.** A mixed feed adiabatic flash calculation. **10.** Adiabatic flash. **11.** Isothermal flash. **12.** Flash to a specified quantity of vapor. **13.** Absorber/stripper calculation using Edmister short cut.

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# Management Personals

**William Naden,** executive vice president of the Humble Oil & Refining Co., will serve as chairman of the public relations advisory committee of the National Association of Manufacturers during 1961. Naden, who has been a director of NAM the last two years, was a member of the public relations advisory committee last year. He is a director of Humble and formerly was president of Esso Standard Oil Co. until Esso became a division of Humble Oil last year.

**Daniel R. Toll** was elected a vice president of Helmerich & Payne, Inc. Toll has had a wide range of experience with the diversified Tulsa oil company, most recently serving as assistant to the president, manager of exploration and chairman of the executive committee of Engineering-Construction Co., a wholly owned pipeline contracting subsidiary. As vice president Toll will assume additional responsibility in the company's financial affairs.

D. R. Toll

R. A. Coffin

**Royce A. Coffin** was named treasurer. He has occupied the positions of office manager, internal auditor, and assistant to the financial vice president. As treasurer Coffin will also be concerned with the financial affairs of subsidiary and affiliated companies.

**Robert W. Miller** has resigned as a member of the board of Standard Oil Company of California. He is chairman of Pacific Lighting Corporation, which recently organized a subsidiary to go into natural gas. It is possible this might create a question of conflict of interests with StanCal.

**John M. Cooper,** a former Gulf employee who recently retired as assistant managing director of Kuwait Oil Company, Ltd., owned jointly by Gulf and the British Petroleum, has been awarded the insignia of "Honorary Commander of the Most Excellent Order of the British Empire." The award was made by the Minister of Power on behalf of the Queen of England in recognition of his valuable service to British official interests.

Cooper joined Gulf at Hull, Texas, in 1923 after completing his production engineering work at Carnegie Institute of Technology, Pittsburgh.

**O. L. Polson** was appointed domestic purchasing supervisor for Gulf Oil Corporation with headquarters at Houston. He will be responsible to **K. E. Rotegard,** recently designated manager of domestic services department.

Polson has been associate director of purchasing at the company's general office in Pittsburgh. In his new position, he will guide Gulf's purchasing activities for the domestic operating departments which are now concentrated in Houston.

**Richard W. White** was named insurance coordinator succeeding **J. H. Van Eman,** retired.

White, formerly an insurance analyst for Gulf, will also be responsible to Rotegard.

**Claude O. Stephens,** president of Texas Gulf Sulphur Company, was named chief executive officer, succeeding **Fred M. Nelson,** who retired.

Stephens, president since March 1957, has spent his entire career with Texas Gulf, joining the company in


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1932 upon graduating from Louisiana State University. After service as a field engineer and later as manager of Wyoming operations, he became manager of the gas department in 1951. He was elected a vice president the following year and became a director in 1956.

▸ **S. H. McManus,** comptroller and a 40-year veteran of the Sinclair organization, was elected as a vice president of Sinclair Oil Corporation. He began his career with Sinclair in 1920 in the auditing department, named chief in 1943. He was elected assistant comptroller in 1950 and comptroller in 1954.

▸ **J. Howard Marshall II** was appointed president and chief executive officer of Union Texas Natural Gas Corporation succeeding **Richard T. Lyons,** retired. Marshall was also named a director and member of the executive committee. **John T. Oxley** continues as executive vice president.

Marshall formerly was executive vice president of the Signal Oil and Gas Company of Los Angeles.

▸ **Walter Wilds** has been appointed manager, Pittsburgh Foreign Section, Treasury Department of the Gulf Oil Corporation. He succeeds **J. E. Allen,** who is retiring after 30 years of service with the company. In his new position, Mr. Wilds will be responsible for the coordination and establishment of bank accounts and loan agreements in the Western Hemisphere, other than the United States, Canada, and Venezuela; and advise and assist in a similar capacity in the Eastern Hemisphere.

▸ **Bernard F. Klein,** a petroleum engineer, has become senior vice president and technical director of Advertising Engineers, Inc.

▸ **Clifford V. Shireman** was appointed to the newly created position of manager, economic analysis, of California Oil Company. Shireman will be succeeded as superintendent-planning in the refining division by **James J. Motroni.**

A graduate of the University of Washington, Shireman joined Caloil at Perth Amboy as a project engineer in 1949. Motroni, a senior analyst in the refiner's office, joined Caloil in 1950 as an engineer in the company's process development section.

▸ **Dr. G. D. Brunton** was named president of the new Pure Oil Company branch of the Scientific Research Society of America. **Dr. M. A. Rosenfeld** and **Dr. G. W. Crosby,** past presidents of the Pure Oil Research Society, received individual recognition for the part they played in forming the society.


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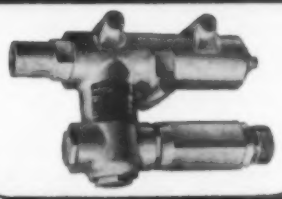
*Specify* *Amot controls*

**They Give Your Engines Maximum Protection!**

AMOT Model 4023 High Pressure Valve has balanced 3-way action. Suitable for pressures from 250 to 6000 psi.



AMOT Model 4021 Temperature Valve has a balanced 3-way action for pilot pressure control in any control system. Actuating temperature settings from 95 to 235° F. Available also with extensions.

AMOT Model B Thermostatic Valve has become Industry's STANDARD for Engine, Compressor, and Process temperature control. It is tamper proof. Available in 1½" to 6" in cast iron, ductile iron or bronze.

*Amot controls* CORPORATION

THERMOSTATS · CONTROLS · SWITCHES · VALVES · SAFETY CONTROLS

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▸ **J. Harold Perrine** was appointed director of industrial relations of Sun Oil Company. Succeeding him as assistant director is **John H. Ashenfelter,** now an assistant to the director.

**George J. Bauer,** manager of the editorial services of division of Sun's public relations department, has retired. His duties included general supervision over the publication of *Our Sun*. Although he contributed to *Our Sun* from its beginning, performing advertising duties as well, he did not become the publication's full-time editor until 1936, when he became supervising editor of all publications.

▸ **Ivan M. Fischer** was named "salesman of the year" at the annual meeting of the Lone Star Steel Company sales force announced **Walter T. Moreland,** vice president of sales.

▸ **H. Walton Musick** was named director of purchases of Kerr-McGee Oil Industries, Inc. Musick previously served as assistant director of purchases and also manager of the office services department.

▸ **R. A. Arzinger** retired as treasurer of the American Oil Company after 37 years of service. He is a member of the Finance and Accounting Committee, American Petroleum Institute.

C. W. Fendrich, Jr.

▸ **C. Welles Fendrich Jr.** was appointed director of marketing research of Walworth Company. He will help develop new markets and coordinate marketing procedures for Walworth's complete bronze, iron, steel, PVC, and lubricated plug valve line.

W. Dow Hamm

▸ The Atlantic Refining Company announced the election of **W. Dow Hamm** as a director of the company. He succeeds **L. A. Sunkel,** who is retiring after 42 years of service. Hamm was named a vice president and general manager of the crude oil production department on March 15, 1960. He was previously manager of domestic and foreign exploration.

▸ **Thomas E. Monaghan,** general counsel to Standard Oil Co. of New Jersey, is heading the petroleum division in The Legal Aid Society's 1961 campaign for funds.

▸ **Carrol M. Bennett** was named to the newly-created post of president of Frankfort Oil Company, Dallas-based division of Joseph E. Seagram & Sons Inc., New York.

Bennett, veteran of more than 25 years in the oil business, has been director of oil operations since 1956. He will continue also as head of Carrol Bennett & Associates, financial-management consulting firm.

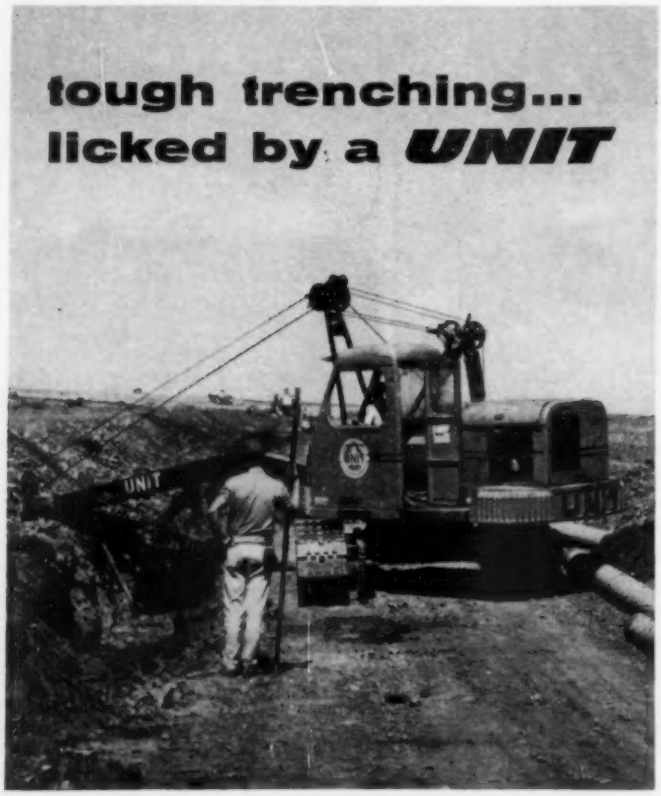
## DEATHS

▸ **Ernest Utterback,** who retired from Socony Mobil Oil Company, Inc., April 1960 after 27 years of service, died December 29 in La Mesa, Calif. He had been manager of the design division of the engineering department.

▸ **Roscoe R. Smith,** 61, vice president and sales manager of the Durametallic Corporation, died December 15.

▸ **Plummer T. Dunkle,** 54, superintendent of the Cleveland division of The Buckeye Pipe Line Company died December 17 at his home in Lima, Ohio.

▸ **Charles Bunje Jr.,** 79, former Ohio Oil Company official, died December 11 in Santa Monica, California. At the time of his retirement from Ohio Oil in February 1946, he was vice president and manager of the company's pipe line operations. He had moved to the West Coast following his retirement.


In constructing a 12-in. line for the Oklahoma Natural Gas Co., Pipeline Service Company, Lindsay, Oklahoma, had tough going. There's no doubt about it; look at that rocky spoil! This is digging that only the best in trenchoes could tackle. Handling it . . . a UNIT ¾-yd. Model 1020A.

UNIT trenchoes are built for rugged digging. UNIT's unique direct-in-line power transmission design pays big dividends in output. Power is transmitted through a worm-driven power take-off with "one step" speed reduction. There's little power loss through friction. You get steady dipper pull.

UNIT trenchoes keep going, too, without excessive downtime. Track and turntable rollers, gears, and shafts are forged for uniform toughness. Shafts are involute splined for greatest strength. All gears, shafts, and bearings are enclosed in a constant oil bath.

UNIT trenchoes are available in ½- to 1-yd. sizes . . . are fully convertible to dragline, crane or clam — on crawler or rubber. See your UNIT distributor for complete information on the size that fits your needs.

UNIT

UNIT CRANE & SHOVEL CORP.
6603 W. Burnham Street
Milwaukee 19, Wisconsin

# READING FOR MANAGEMENT

▸ **"Ends and Means of Modern Management,"** *AMA Management Report Number 30. Published by General Management Division, American Management Association, Inc., 1815 Broadway, New York 36, New York. 158 pages. Price, $3.75/AMA members: $2.50.*

The primary duty of those who carry managerial responsibilities is to be efficient at their tasks. Yet important as such functional efficiency is, it is becoming increasingly evident that it is not enough.

For the professional manager of today it is also necessary to strive constantly to effect improvement in the environment within which the struggle for corporate survival and profitability is carried on. To this end, he must seek to understand and influence the economic, technological, social, and political forces which shape this external environment.

This volume reports the experiences and opinions of some of this country's leading business executives in these major areas of managerial responsibility.

Grouped under "Some New Dimensions" are such titles as "Evolution of a New Economic System," "A Program For Political Action," "The Management of Change," "Strategic Use of Research," and "Some Aspects of Management of Foreign Operations." These titles give you an idea of the scope of the essays.

▸ **"Information and Communication Practice in Industry,"** *edited by T. E. R. Singer. Published by Reinhold Publishing Corporation, Dept. B-185, 430 Park Avenue, New York 22, N. Y. 296 pages. Price, $8.75.*

This handbook, edited by a technical information consultant, is written by experienced men and women to explain a great many phases of communication methods. There are information departments, internal communications, operations research, technical classification, organization of classified patent collections, mechanical aids, punched-card methods, technical writings and illustrations, editing technical reports, fundamentals of designing tables, indexing, abstracting . . . in fact, you'll find almost every means of communicating covered in practical fashion

Some chapters have excellent references. We, of course, were interested in the one on technical writing which is brief and well written.

▸ **Technical Writing Techniques,** *by Joseph Racker. Published by Prentice-Hall, Inc., Englewood Cliffs, New Jersey. 234 pages. Price $6.95.*

Written by an engineer for those engaged in technical writing, this book presents a specific set of rules for writing in the engineering field.

There is a detailed treatment of all phases of technical writing: illustrations, Government specifications, terminology, etc. It shows the engineer how to select the elements of his material, how to organize them, and how to present them to technical personnel of all levels.

▸ **"The Man On Your Back"** *by Wyatt Marrs. Published by The University of Oklahoma Press, Norman, Oklahoma. 289 pages. Price, $3.95.*

In this social study the author tells of the countless parasites feeding on everyone who engages in productive activity. As he says, "Close and prolonged association has tended to blind us to this unequal situation, at least in most cases, to the point of passive acquiescence." He adds that man has gradually freed himself from most of the dangers and handicaps of his life, but he is in serious danger from certain elements of the human population itself.

From the crippled beggar on the street corner to the dictator who practices international robbery on a grand scale, modern civilization is beset on all sides by those who have "the itch to get something for nothing" — so much so, in fact, that social parasitism is society's most deadly enemy. It is more deadly and menacing because it takes so many forms, some even imitating socially useful activities, and, in its less obvious aspects, parasitism has in certain areas of society become a desirable and even an envied state.

Because of these parasites, everyone who engages in productive activity is made to suffer serious and continuous economic loss. There is widespread want when storehouses are full, primarily because of those who take without giving and consume without producing. And the social loss is even more staggering.

Some of Wyatt Marrs' conclusions will shock the average citizen, but the truth of his assertions is unassailable and inescapable. Thinking persons everywhere will profit from the frank treatment of the dilemma described in "The Man on Your Back."

▸ **"The Dynamics of Management,"** *AMA Management Report Number 14. Published by General Management Division, American Management Association, Inc. 139 pages. Price, $3.75/AMA members: $2.50.*

This report is concerned with the various forces operating today in the field of business management. Broadly, these forces may be regarded as being of two distinct types — external and internal — though in practice, of course, it is to meet the demands of some external change, actual or impending, that most internal business changes are made.

The external forces with which the authors of this volume are concerned are the changing economic, social, and political patterns of our environment. The internal forces are the thoughts and actions of America's business leaders. Needless to say, these internal forces are of as many kinds as there are individual business men.

Several articles by executives deal with these topics: "Meeting the Challenge of Change," "Broadening Responsibilities of Business," "Planning for Corporate Growth," and "Improving Individual and Group Efficiency."

▸ **Twentieth Century Petroleum Statistics 1960"** *published by DeGolyer and MacNaughton, 5625 Daniels Avenue, Dallas, Texas. 88 Charts. Price, $7.50.*

The office of the Director of Naval Petroleum and Oil Shale Reserves in 1945 prepared a volume of data called *Twentieth Century Petroleum Statistics.* At the request of the director, Commodore W. G. Greenman, U. S. Navy, the handbook has been published on an annual basis by DeGolyer and MacNaughton, Dallas, Texas. The statistics cover mainly United States, although there is some reference to world petroleum operations. Graphs and tables provide figures for crude production, reserves and refining capacity on a world-wide basis.

▸ **"How to Invent"** *by Forrest E. Gilmore. Published by Gulf Publishing Company, P. O. Box 2608, Houston 1, Texas. 89 pages. Price, $2.95.*

This thin volume will give you plenty to think about whether you ever become an inventor or not. It should give you ideas on how to be one if you have any desire along that road. It explains how to keep away from "think killers." There are explanations that tell you:

How to use your intuition and imagination.
How to prepare for invention.
How to set the stage for illumination and inspiration.
When and where to invent.
Why you should learn to invent.
What rewards you can reap from inventing.

You will find that learning how to invent can be an interesting and profitable occupation.

▸ **Comprehensive Report on Wyoming's Oil and Gas Fields,** by *Paul Briggs and Ralph H. Espach, Bureau of Mines petroleum engineers, in cooperation with the Missouri Basin Field Committee. Compiled by the Bureau of Mines and distributed through the Government Printing Office, Washington, D. C. Pages, 538. Price, $4.25.*

The report constitutes a complete account of 271 oil and gas fields in Wyoming and contains many items that may prove of interest to the thousands of small investors and landowners concerned with Wyoming's petroleum and natural gas resources. In addition to its 171 maps, the sales publication gives analysis of 418 crude-oil samples, representing the largest collection of such information ever published on Wyoming petroleum—plus a brief history of the industry in Wyoming. There is also a listing of an analysis of 183 natural gas samples and tabulations of 334 oilfield water samples. Overall, the Bureau predicts a bright future for Wyoming petroleum industry and points out that in 1957 alone, 18 new oilfields were discovered.

▸ **Simplified Fr-Y Factors,** *by John P. Squier. Published by John P. Squier Company, Gas Measurement-Engineering Service, Box 6100, Dallas 22, Texas. Pages 78. Price $25.*

This small volume contains a complete set of combined Reynolds Number and Expansion Factors compiled from basic A.G.A. formulae to save time and labor in gas measurement calculations.

The factors are easily obtained by knowing only the d/D ratio and reading the combined factor directly from headings of line size, gage pressures, and differential. In order to condense this information, the tables are based on upstream static connections for pipe taps, and downstream static connections for flange taps.

Tables are especially adaptable to installations where there is variance in pressures or differentials from day to day, and for operators who incorporate such factors in the hourly meter coefficient.

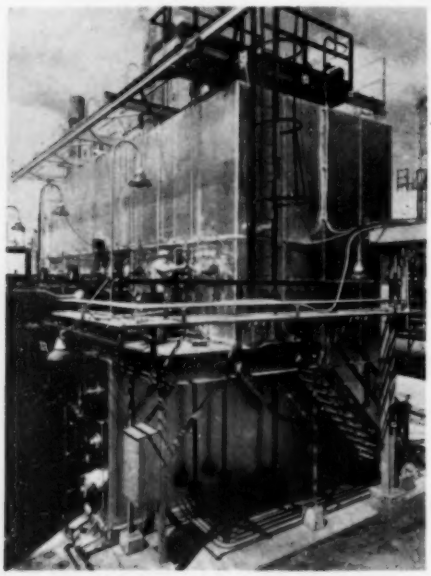
▸ **Ultrasonic Welding,** *American Welding Society, 33 West 39th Street, New York 18, New York. 38 pages, 29 illustrations. Price, $1.50.*

A reprint of material published in Section III of the "*Welding Handbook*" (fourth edition), this booklet discusses fundamentals of this process which are regarded by some as having the greatest potential for future development.

Sections discuss the metals which can be welded, welding techniques, weld characteristics, quality control, equipment, and applications. A brief bibliography and index are included.

▸ **Oil & Petroleum Year Book 1960,** *compiled by Walter E. Skinner, 20, Copthall Avenue, London, E. C. 2. 790 pages. Price, $7, post free.*

This fifty-first edition of the Year Book features the following sections: "World Oil Companies," containing a complete up-to-date data listing of 1100 principal world oil companies and covers all branches of the industry: "International Buyers' Guide," with over 2000 heading and entries of international manufacturers and suppliers of petroleum equipment; "Managers, Engineers & Agents," 730 names and addresses of personnel and the companies they are associated with; "World Crude Oil & Natural Gasoline Tables," showing annual production in individual countries from 1950-1959; plus a variety of illustrative maps and charts indicating world oil supply and demand. Of particular note is a new feature depicting the product demand by end use of the U. S. and Europe in 1959.

This insulated

# LINDSAY STRUCTURE "JACKET"

## . . . keeps below zero temperatures **inside!**

The all-steel Lindsay Structure housing pictured, was designed and installed by Badger Manufacturing Company, Cambridge, Massachusetts, for a major refinery. It protects a unit producing Paraxylene, the chemical base for synthetic fibres used in shrink-proof fabrics. Lindsay components were incorporated into the design to provide a "tailored" weather-tight "jacket" for the complex equipment used in processing. In addition to the advantages of an all-steel housing which could be efficiently insulated and sealed, the Lindsay method of construction facilitated on-the-site erection in a congested area.

**LINDSAY STRUCTURE DIVISION — International Steel Company**

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This is just one example of how Lindsay Structure is used by the petroleum industry. Other typical applications include: housings to protect instruments and equipment; pumping stations and other pipeline installations; truck and trailer bodies; special-purpose buildings; and many other types of enclosures.

Gentlemen: Send me your manual "The Modern Method of Using 'Pre-Tensed' Sheet Metal" . . . for building Housings, Enclosures, Containers, Processing Towers, Portable Shelters, etc.

NAME _____ TITLE _____

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## Laugh with Barney

A young lady on a vacation cruise stopped a sailor at his job and asked, "I'd like to see the captain of this ship."

"He's forward, Miss."

"Well, I don't mind. This IS a pleasure trip."

Only mosquitoes like girls with fat legs.

Three successive notices from a small country paper tell their own story:

November 2: "For sale. Slightly used farm wench, in good condition. Very handy. Apply A. C."

November 4: "Correction. Due to an unfortunate error, Mr. Cartwright's ad last week was not clear. He has an excellent winch for sale. We trust this puts an end to the jokesters who have telephoned Mr. Cartwright and bothered his housekeeper, Mrs. Hoff, who loves with him."

November 6: Notice—My winch is not for sale. I put a sledgehammer to it. I have had the telephone disconnected. I am not carrying on with Mrs. Hoff. She merely LIVES here.—A. Cartwright."

And speaking of mistakes, a linotype operator misplaced an "m" for a "b" and caused the following to appear in a divorce story: "Mrs. Jones asks a divorce from Mr. Jones declaring he has amused her physically."

The beautiful actress was visiting a military hospital. "Did you kill the enemy?" she asked the occupant of the first bed.

"Yes, lady," he said.

"Which hand did you use?"

"My right."

The actress took his right hand and kissed it.

The turn of the man in the next bed came. 'I killed hundreds of 'em," he said.

"And which hand did you kill them with?"

He leaned forward eagerly. "I bit them to death!"

A despondent old gentleman emerged from a night club and climbed into his limousine.

"Where to sir?" asked the chauffeur.

"Drive off a cliff, James, I'm committing suicide."

Daughter: Well, there's one thing about it, I'll never marry a man who snores.

Mother: That's fine. Just be careful how you find out.

Overheard in a parked car: Hands off, Columbus, you've discovered enough.

There's no thrill like kissing a girl and dropping an ice cube down her back at the same time.

The father, passing through his son's college town late one evening, thought he would pay his son a surprise visit. Arriving at the son's fraternity house, he rapped on the door but was unable to rouse anybody. Then from a second floor window came a sleepy voice.

"Whaddyah want?"

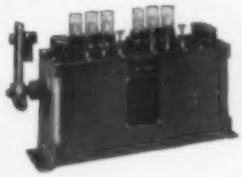
"Does Steve Jones live here?" said the father.

"Yeah," replied the voice. "Bring him in."


# HOW TO educate

# a drop of oil!

Just put it through a Manzel force-feed lubricator and any oil drop knows where it's going and how to get there fast. Manzel lubricators deliver just the right amount of oil to bearings, cylinders and packings. They start, stop, speed up and slow down in perfect synchronization with your machinery...unaffected by high steam, gas or air pressure. Whatever your field, there's a Manzel lubricator to meet your needs. For our catalog, write Manzel, 255 Babcock Street, Buffalo 10, New York. Whatever your lubricating problem, you get the right answer if you



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Position available for graduate Chemical Engineer with minimum 2 years' experience processing work on light hydrocarbon or petrochemical plants. Call or write

T. D. TABBERT
*Chief Process Engineer*

**THE FISH ENGINEERING CORP.**
796 M & M Building Houston, Texas

**ADVERTISING SALES OR PROMOTION**

Trainee for leading oil, gas, petro/chem publications. Must be personable, intelligent, tactfully aggressive. He could be a graduate in advertising, marketing, journalism, or a petroleum, mechanical or chemical engineer presently employed in the oil-gas industry. Writing aptitude important. Excellent opportunity for young man of right qualifications. *Apply by letter and resume to* P. O. Box 1389, Dallas, Texas, *sending qualifications, telephone number and photo. Replies will be held in confidence.*

## Meetings . . .

Feb. 14 — **PESA**, Eastern District, Duquesne Club, Pittsburgh, Pa.

Feb. 14-15 — **NACE Short Course**, Shreveport Section, Centenary College, Shreveport, La.

Feb. 16 — **National Industrial Conference Board**, meeting of board members, Waldorf-Astoria Hotel, New York City.

Feb. 23-25 — **Pipe Line Contractors Association of Canada**, Empress Hotel, Victoria, British Columbia.

Feb. 24 — **Natural Gasoline Assn. of America**, South Louisiana regional meeting, Lafayette Petroleum Club, Lafayette, La.

Feb. 26-Mar. 2 — **Society of Petroleum Engineers of AIME**, annual meeting, Chase and Park Plaza Hotels, St. Louis, Mo.

Mar. 2 — **PESA**, North Mid-Continent District, Mayo Hotel, Tulsa.

Mar. 7 — **PESA**, Pacific District, Ambassador Hotel, Los Angeles, Calif.

Mar. 8-10 — **API Division of Production**, Southern District meeting, Captain Shreve and Washington-Youree Hotels, Shreveport, La.

Mar. 13-17 — **National Assn. of Corrosion Engineers**, annual meeting and corrosion show, Hotel Statler, Buffalo, N. Y.

Mar. 15-17 — **Natural Gasoline Assn. of America**, 40th annual convention, Baker Hotel, Dallas, Texas.

Mar. 20-24 — **12th Western Metal Congress and Exposition**, Pan-Pacific Auditorium, Los Angeles, Calif.

Mar. 22-24 — **API Division of Production**, Southwestern District meeting, Cole Hotel, Albuquerque, N. M.

Mar. 23 — **National Industrial Conference Board**, general session, Shamrock-Hilton Hotel, Houston, Texas.

Mar. 27-29 — **Midwest Gas Assn.**, annual meeting and convention, Sheraton-Fontenelle Hotel, Omaha, Neb.

Mar. 27-31 — **ISA**, 3rd Symposium on Temperature, Veterans Memorial Auditorium, Columbus, Ohio.

Apr. 4-5 — **Gas Compressor Institute**, Liberal, Kan.

Apr. 5-7 — **API Division of Production**, Mid-Continent District meeting, Mayo Hotel, Tulsa, Okla.

Apr. 5-7 — **Kansas Oil Men's Assn.**, Management Institute, University of Kansas, Lawrence, Kan.

Apr. 7-9 — **Southwestern Alaskan Chapter AIME**, Sixth Annual Mining, Minerals & Petroleum Conference, Anchorage, Alaska.

Apr. 9-11 — **14th Annual Midwestern meeting**, Society of Exploration Geophysicists, Oklahoma City.

Apr. 10-13 — **American Society of Mechanical Engineers**, 33rd annual conference and exhibit of the Oil and Gas Power Division, Jung Hotel, New Orleans, La.

Apr. 17-19 — **ISA**, 7th National Symposium, Shamrock-Hilton Hotel, Houston, Texas.

Apr. 18-20 — **Southwestern Gas Measurement Short Course**, University of Oklahoma, Norman, Okla.

Apr. 28 — **Natural Gasoline Association of America**, Oklahoma Regional Meeting, Lake Murray Lodge, Ardmore, Okla.

May 12 — **Natural Gasoline Association of America**, Permian Basin Regional Meeting, The Lincoln Hotel, Odessa, Texas.

June 6-8 — **Appalachian Corrosion Short Course**, West Virginia University, School of Mines, Morgantown, West Virginia.

July 26-28 — **API**, Eastern District, Division of Production, Greenbrier Hotel, White Sulphur Springs, West Virginia.

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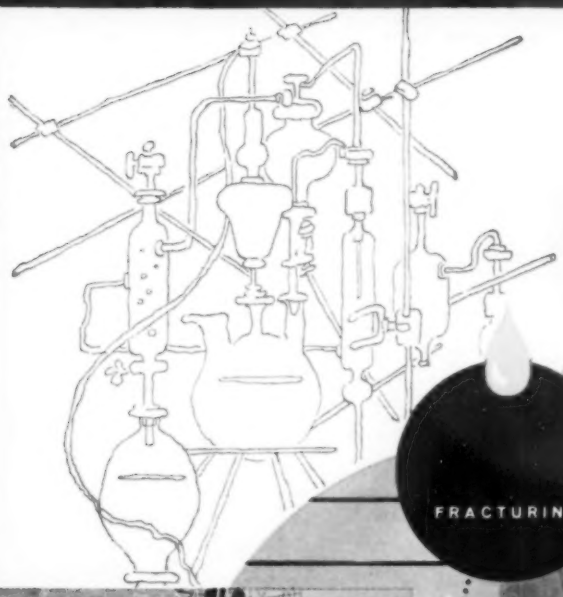

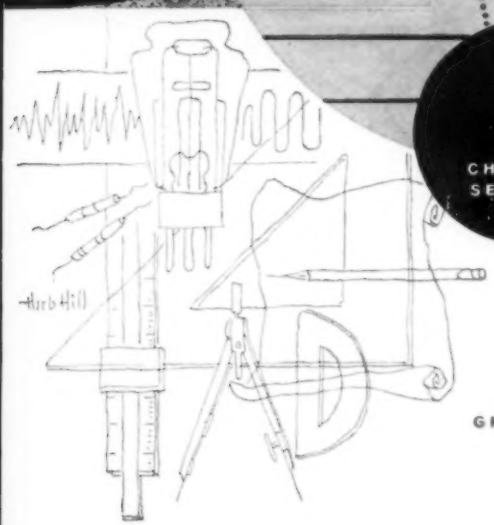

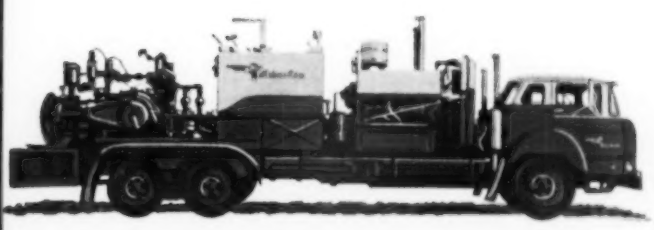

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FRACTURING

CEMENTING

CHEMICAL SERVICES

SPECIAL PRODUCTS & SERVICES

GROUTING

WATER WELL

Halliburton's dedication to complete service to the oil industry has resulted in the accomplishment of leadership in the four major areas of oil well services – testing, fracturing, cementing, and chemical services. Each of these departments within the Halliburton organization is supported by its own research and development teams, manufacturing units, and field service experts. Each has been responsible for bringing revolutionary developments to its own segment of the industry, making possible the evolvement to today's modern drilling and producing practices.

## THE WORLD OF HALLIBURTON

Recently another entity was added to provide other industries with special products and services that, where applicable, will bring new technological advancements for the benefit of diversified interests.

The world of Halliburton has as its axis—service. It will continue to devote its manpower and energies to the service of the oil and gas industry as its main purpose while always being alert to the requirements of others.

**Halliburton**
COMPANY · DUNCAN, OKLAHOMA

# *Today's Discoveries Are Yesterday's Dry Holes*

Welex's Simplified Logging Program today logs many discovery wells in areas once called "dry hole" country.

Thanks to modern techniques, such as the Welex program, you can now pinpoint and produce profitably many pay sands, ignored by old-fashioned logging tools a few years ago.

The Welex Simplified Logging Program does this for you ACCURATELY and FAST.

Introduced to eliminate confusion and complicated computations, the Welex program within minutes gives you the answers to the two main questions — WHAT IS THE POROSITY and WHAT IS THE FLUID SATURATION.

Based on only two factors — type of porosity present and drilling mud/formation water salinity contrast — the Welex Simplified Logging Program makes selection of the BEST LOGGING PROGRAM for every well easy, as shown by the diagram here.

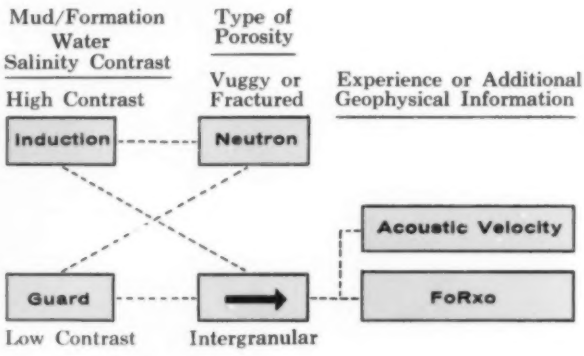
The addition of Welex's Acoustic Velocity Log to the program makes even more information available to you. The Acoustic Velocity Log is the ideal choice when used in:

1. Formations where experience or past performance indicates that its porosity values are more accurate.

2. Areas where velocity data is desired for geophysical purposes.

As with the Welex FoRxo and Neutron Logs, you can read porosity values directly off the Acoustic Velocity Log. When run in conjunction with the Welex Induction or Guard Log, your most important question — WILL THE WELL PRODUCE? — can be answered in minutes by using the Simplified Interpretation Charts or "pigtails" printed right on the log.

The Welex Simplified Logging Program IS THE ANSWER for your well.




COMPLETE WIRELINE Welex SERVICES

# WELEX

A Division of Halliburton Company

*General Offices: 1728 Old Spanish Trail, Houston, Texas*

# Of Things To Come . . . In Oil

FIRST PRIVATELY OWNED HELIUM PLANT in the U. S. will be built by Kerr-McGee Oil Industries, Inc., in the Pinta field, Apache County, Arizona. Designed to process 2.5 million cu ft of gas a day, the plant will handle Pinta field gas containing about 8 percent helium and the product will be supplied directly to the commercial market. Company engineers calculate recoverable reserves of pure helium in the field at 600 million cu ft.

FIRST OCEAN FLOOR COMPLETION OFF CALIFORNIA is being planned by Richfield Oil Corp. on its state oil and gas lease at Rincon, Ventura County. Following several such completions by the company in Peruvian offshore waters, the California completion will enclose the production head in a covered protective steel cylinder rising 12 ft above the ocean floor. Top of the cylinder will be more than 50 ft below ocean surface at low water. Production to land will be through three 2-in. pipelines.

CALIFORNIA WATERFLOOD UNITS WILL CONTINUE INCREASE in 1961 after a 67 percent rise during the past two years. Recent study shows 55 waterfloods in California on June 1, 1960, accounting for 322 injection wells into which water was being injected at a rate of 497,895 bbl per day. Study was made by University of Southern California professor N. van Wingen in cooperation with Tidewater Oil Company.

OIL WILL HIGHLIGHT ALASKA'S FINANCIAL PICTURE, according to the new state's governor, William A. Egan. The governor noted that year-end 1960 saw 19 producing wells in the state and plans for more than 25 new wells this year. Petroleum industry expenditures in Alaska amounted to more than $31 million during 1960 in addition to acreage rental payments and bonuses.

1961 DRILLING WILL FEATURE MORE DEEP HOLES as several wells planned below 20,000 ft are already spudded. One well in South Louisiana is projected to 26,000 ft and will be the world's deepest . . . if. One major drilling contractor is presently at work on more deep holes than the previous total he has drilled. Much success of deep drilling is attributed to methods and techniques developed in recent slim hole drilling projects.

# Arkansas Drilling Costs Cut With ATLAS EMULSIFIER

## $6,843 Saved in 3900′ Comparison

Following the operator's success in drilling with Atlas Emulsifier in Mississippi, Arkansas Fuel Oil Corporation and Montgomery Drilling Company pioneered the use of these drilling fluids in Columbia County, Arkansas. A direct comparison of their recently drilled Deltic Farms and Timber Company No. 1 with Arkansas Fuel's nearby Murphy No. 1 demonstrates the economy of utilizing Atlas oil-in-water emulsion muds. Murphy No. 1 was drilled a year earlier with a gel mud program typical of the Columbia County area. Even with the disadvantage of smaller equipment, the comparison interval was drilled in seven fewer days. Also, nine less bits were used to drill equivalent footage. Taking a rig cost of $900 per day and bit costs of $235 each, the savings total $8,415. Adjusting for the difference in mud bills (including diesel oil in the emulsion) the well shows a net saving of $6,843. Fewer days on the well often cut costs other than those noted above. In the case of Deltic Farms and Timber Company No. 1, 5½ fewer days to go from 6,200′ to TD made possible the earlier release of a logging unit and an additional saving of $165 a day.

**DRILLING RECORD COMPARISON**

| | Deltic Farms & Timber Co. No. 1 | Murphy No. 1 |
|---|---|---|
| Mud | Trimulso Emulsion | Gel Mud |
| Interval | 4812 - 8780 | 4971 - 8761 |
| Feet Drilled | 3968 | 3790 |
| Drilling Days | 24 | 31 |
| Feet per Day | 165 | 122 |
| Drill Pipe | 4″ | 4½″ |
| Drill Collars | 15 | 15 |
| Pumps | 1 - 6½ x 16 | 1 - 6 x 20 |
| Bits | 31 | 40 |
| Feet per Bit | 125 | 95 |
| Weight on Bit | 30 - 35,000 | 35,000 |
| Liner Sizes | 6½″ | 6″ |
| Mud Cost | $5,520 | $5,398 |
| Oil Cost | $1,450 | 0 |

**$6,843 saved**

**Atlas emulsifier is sold through distributors under these tradenames . . . each is the product of Aquaness Department, Atlas Powder Company:**

**TRIMULSO®**

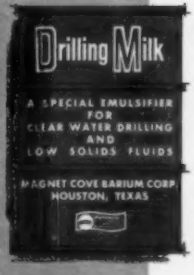
Distributed by Baroid Division, National Lead Company

Registered trademark Baroid Division, National Lead Company

**DRILLING MILK**

Distributed by Magnet Cove Barium Corporation

Registered trademark Magnet Cove Barium Corporation


Drilling Milk
A SPECIAL EMULSIFIER FOR CLEAR WATER DRILLING AND LOW SOLIDS FLUIDS
MAGNET COVE BARIUM CORP.
HOUSTON, TEXAS

**ATLOSOL**

Distributed by Milwhite Mud Sales Company and other selected mud companies

Registered trademark Atlas Powder Company

**ATLAS EMULSIFIERS IMPROVE A GOOD DRILLING FLUID**

**Because Atlas oil-in-water emulsion muds provide better oil action, they improve hole conditions, extend bit life, and increase penetration rates.**

**Better Hole Conditions.** Atlas oil emulsion decreases torque as much as 50% . . . the hole is kept cleaner and pump pressures are correspondingly lower. There is less danger in lost-circulation and low-pressure zones.

**Longer Bit Life.** Atlas oil emulsion prevents balling, provides better cutter and bearing lubrication. Greatly extended bit life reduces bit costs, reduces rig hours lost to trip time.

**Faster Drilling Rates.** Atlas oil emulsion makes more feet of hole per hour. Oil lubrication combines with improved hole condition to increase drilling rates in competent and troublesome formations.

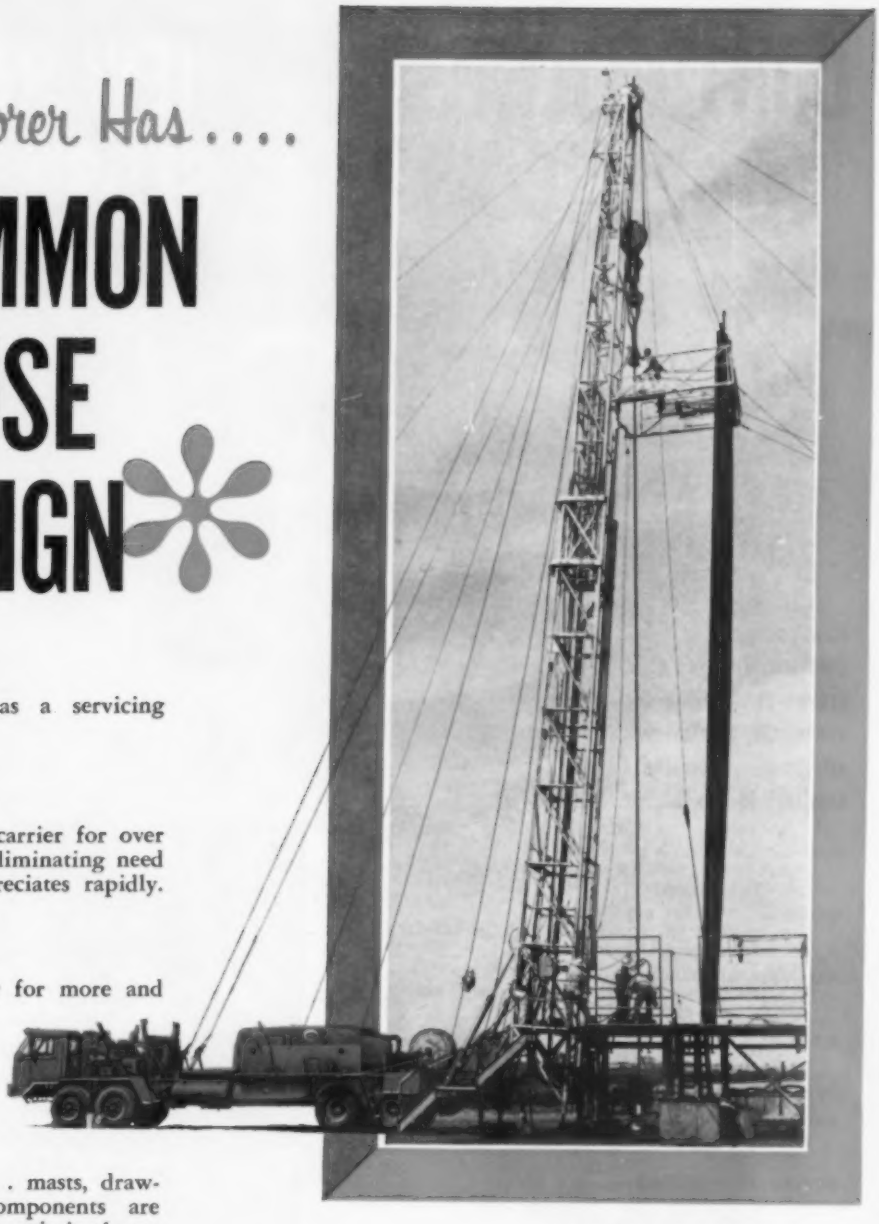
ATLAS Aquaness CHEMICALS ATLAS POWDER COMPANY

Aquaness Department, Atlas Powder Company
P. O. Box 21072 • Houston 26, Texas

127

*Franks Explorer Has....*

# COMMON SENSE DESIGN*



***CSD...**

Primarily designed as a servicing and workover rig.

***CSD...**

Mounted on rugged carrier for over the road travel . . . eliminating need for truck which depreciates rapidly.

***CSD...**

Industrial horsepower for more and faster work.

***CSD...**

Greater flexibility . . . masts, drawworks and other components are interchangeable. Your unit is always up-to-date.

More Franks Explorers are sold than any other competing make — pretty good proof that the Franks Explorer **packs more punch!** Ask your Franks Representative for the facts.

WELL SERVICING AND DRILLING UNITS

FRANKS

PAMPA, TEXAS

CABOT

CABOT CORPORATION
MACHINERY DIVISION

*Worth more when you BUY 'EM . . . Worth more when you TRADE 'EM*

# CONTINENTAL-EMSCO'S

# NEW RANGE OF SLUSH PUMP SIZES

*meets every rig requirement*

The D-375, one of the new sizes of C-E's extended line of modern, proven slush pumps (other sizes in this range, D-125, D-225 and D-550).

**Now you get Continental-Emsco's field proven slush pump engineering and quality control in all sizes . . from the smallest to the largest.**

**FABRIFORM POWER END . .**
easier handling around the rig . . lighter weight without sacrificing strength.

**COMPACT GEAR DESIGN . .**
less weight but more than adequate capacity for today's increased horsepower requirements.

**ROLLER BEARINGS . .**
free rolling action cuts load on prime mover . . extends service life . . no field adjustments required.

**REPLACEABLE CROSSHEAD GUIDES . .**
easy replacement reduces maintenance and down time . . greatly extends usable life of pump . . slippers can be replaced in larger pumps.

**AUTOMATIC LUBRICATION . .**
all parts are automatically lubricated regardless of pump speed.

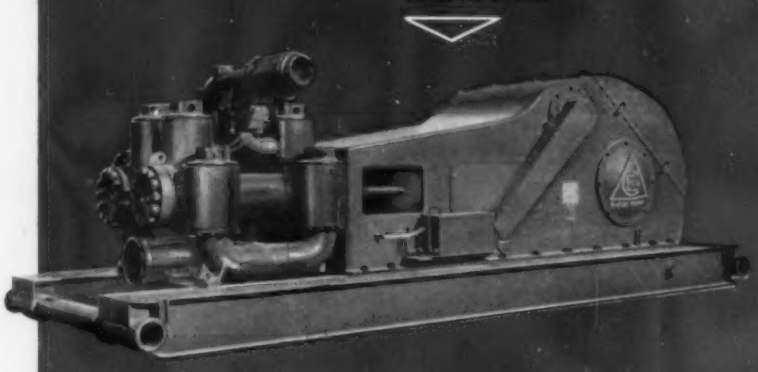
**STEEL FLUID END . .**
designed to handle all muds at highest operating pressures with maximum efficiency.

**PATENTED EXPOSED LINER DESIGN . .**
safeguards against fluid end washouts caused by packing failures.

**THREADED VALVE-POT COVERS . .**
speed up valve inspection, servicing and replacement. Assure maximum fluid flow with minimum turbulence.

**SCREW-TYPE STUFFING BOX GLANDS . .**
assure uniform pressure on packing . . eliminate uneven packing wear, cause of premature packing failure and rod scoring.

Check these features. See why overseas operators, drilling in remote areas, have more confidence in Continental pumps. Regardless of your operation . . local or worldwide . . buy Continental pumps and take advantage of their ability to pump more mud at lower cost.



Pumps for Drilling . . . Mud Mixing . . . Utility

D-1000—Maximum Input . . 1000 hp @ 60 rpm
DA-850—Maximum Input . . 850 hp @ 60 rpm
DA-700—Maximum Input . . 700 hp @ 65 rpm
D-550—Maximum Input . . 550 hp @ 65 rpm
D-375—Maximum Input . . 375 hp @ 70 rpm
D-225—Maximum Input . . 225 hp @ 70 rpm
D-125—Maximum Input . . 125 hp @ 85 rpm

**MANUFACTURED AND SOLD WORLDWIDE BY**

**CONTINENTAL-EMSCO**

*Serving the Oil and Gas Industries ... Worldwide*

SP902

CONTINENTAL-EMSCO COMPANY • A Division of The
Export Division: 30 Rockefeller Plaza, New York, N. Y. • Continental
Continental-Emsco Company C. A. Caracas, Venezuela • Plants: Houston and Garland, Texas; St. Alba

# CABOT 'ROUND-THE-CLOCK Field Service

Day or night . . . 365 days a year . . . Cabot backs each pumping unit with 'Round the Clock field service. This is important because the value of a pumping unit . . . *any pumping unit* . . . is only as good as the service that stands behind it. Cabot has a network of first class service centers throughout the oil country. These centers carry complete stocks of Cabot parts which are taken quickly to your location in special trucks and installed by Cabot factory trained personnel.

If you agree that service is important . . . better try Cabot. CALL YOUR J&L MAN...

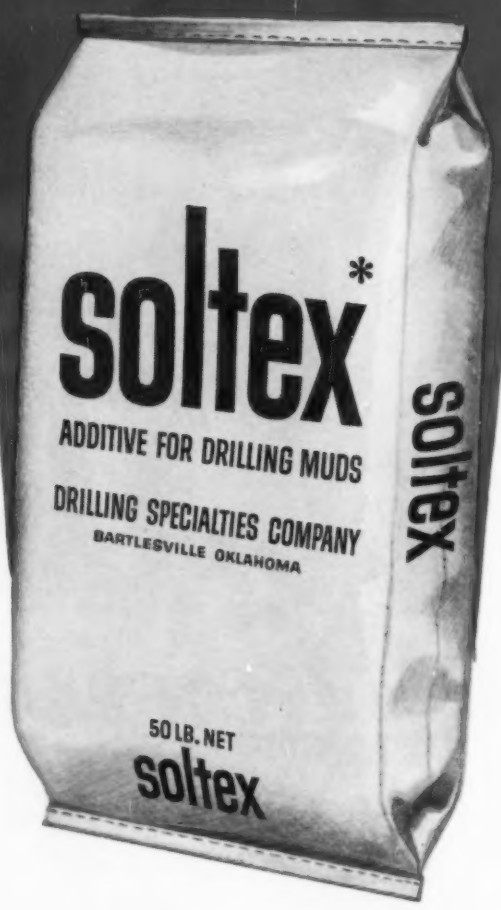
OIL FIELD PUMPING EQUIPMENT
CABOT
PAMPA, TEXAS FRANKS

CABOT CORPORATION
MACHINERY DIVISION

# Announcing...

**A completely new and different drilling mud additive ...SOLTEX offers all these "field-proven" benefits:**

- *Stabilizes Shale Sections*
- *Extends Bit Life*
- *Inhibits Dispersion of Drilled Solids*
- *Replaces Oil in Many Muds*
- *Increases Effectiveness of Driscose**
- *Compatible with Known Mud Formulations*
- *Makes Mud Resistant to High Temperature*
- *Economical and Easy to Use*




SOLTEX—a modified, high molecular weight hydrocarbon compound—is a black, free-flowing, flake material that is soluble in both oil and water. *It was developed primarily for stabilizing shale sections*, but in extensive field applications SOLTEX has proved its successful performance in many varied drilling and completion operations.

The economical addition of SOLTEX to drilling fluids has saved many wells which were scheduled to be abandoned because of formation sloughing, pipe sticking, and lost circulation encountered in highly compacted and horizontally stressed shale sections.

In many test wells drilled under more "normal" conditions, SOLTEX modified drilling muds have produced remarkable savings . . . ranging as high as $23,000 from reduced drilling time, less bit wear, etc. Mud engineers associated with SOLTEX field applications agree . . . "It's one of the most important mud discoveries since DRISCOSE, the original CMC material." When used with DRISCOSE , it further increases the range, speed and over-all economy of your drilling operations.

For more complete information on SOLTEX —contact your mud dealer or see your Drilling Specialties Company representative.

*Trademarks

**DRILLING SPECIALTIES COMPANY**
Bartlesville, Oklahoma

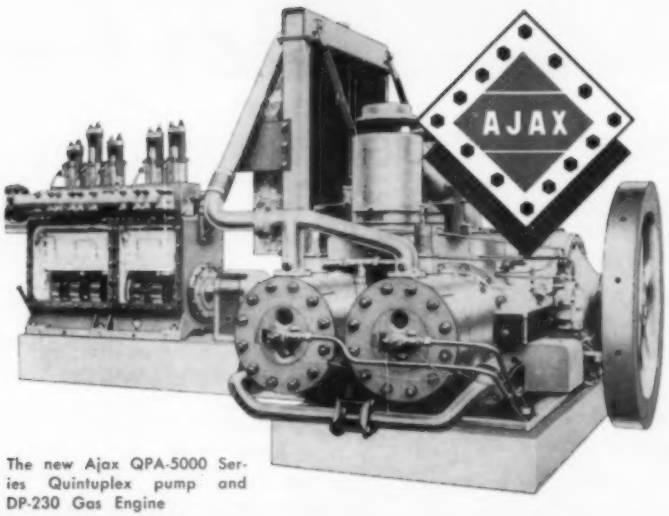


FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

# AJAX Gives You DEPENDABLE OPERATING AUTOMATION

## With BUILT IN POWER SUPPLY

- Stark simplicity of operation and servicing — you don't need a specialist.
- Control engine speed to load and water requirements.
- Engineered to actual horsepower requirements without destructive overload capacity required by instantaneous starting demands




The new Ajax QPA-5000 Series Quintuplex pump and DP-230 Gas Engine

The need for dependable electrical power still remains one of the weak links in the usual automation installation — especially in remote locations and under certain climate conditions.

Ajax time proved engineering has now solved many of the automation-electrification problems. Automation today is economically sound if the equipment and the installation are designed to meet your particular problems. Contact your Ajax distributor today for the full story on automation without external electrification.

Ajax gives you true economy because of simplicity of design, ease of maintenance, extra long life, and 83 years of quality craftsmanship experience.

## AJAX ENGINES AND PUMPS

AJAX . . . also builders of COMPRESSORS

**AJAX IRON WORKS** CORRY, PENNSYLVANIA

*Oil Field Distributors*

- The National Supply Co. — Pittsburgh, Pennsylvania
- Bethlehem Steel Co. — Supply Division, Tulsa, Oklahoma
- Mid-Continent Supply Co. — Fort Worth, Texas

This mark tells you a product is made of modern, dependable Steel.

# Is your sucker rod problem fatigue? Then get tough! Tough steel, that is.

The one outstanding, reasonably priced steel—with *Toughness* to take fatigue—is Boron Alloy steel. But this steel should be *liquid quenched and tempered* for optimum results.

"Oilwell" has exclusive liquid quench—hot straightening equipment. After extensive field tests using this steel in sucker rods, we found it to have remarkable fatigue-resistance under heavy loads. It also performed well under hydrogen embrittlement conditions.

This *Toughness* is offered in the NEW "Oilwell" GRADE "O" SUCKER ROD—complete with the needed liquid quench and temper—priced just above the carbon steel normalized rods.

Try *TOUGHNESS* in your next well. We welcome "alternate rod" tests of Grade "O" against any rod in its low price class—call your nearby "Oilwell" Store. *USS and "Oilwell" are registered trademarks*

**Oil Well Supply Division of United States Steel**

USS

Executive Offices: Dallas, Texas
Export Office: 30 Rockefeller Plaza, New York 20, N.Y.

# "A great step forward with your Planetary Gears, Big Bearings and Cylindrical Crossheads."

— J. K. Butler

**WHELAND PLANETARY**
**HP-16000 PUMP**
**Duplex Power Slush Pump**
**7¾" x 16", 600 H.P. at 65 RPM**

OIL PRODUCTION MAINTENANCE, INC.
7440 CHOCOLATE BAYOU ROAD -- P. O. BOX 14291
HOUSTON 21, TEXAS
August 31, 1960

Mr. Gordon P. Street, President
The Wheland Company
Chattanooga, Tennessee

Dear Mr. Street:

Our Wheland Planetary Pump is giving us increased penetration and good savings on bits. We know from more than 18 months of constant operation on 10,000 Ft. wells that our savings are substantial.

We have kept an accurate record on operating costs and all maintenance costs and are especially impressed by the low cost of fluid end expendables. The HP-16000 Pump has constantly operated near its rated capacity on more than 200,000 feet of hole in the Texas Gulf Coast Area.

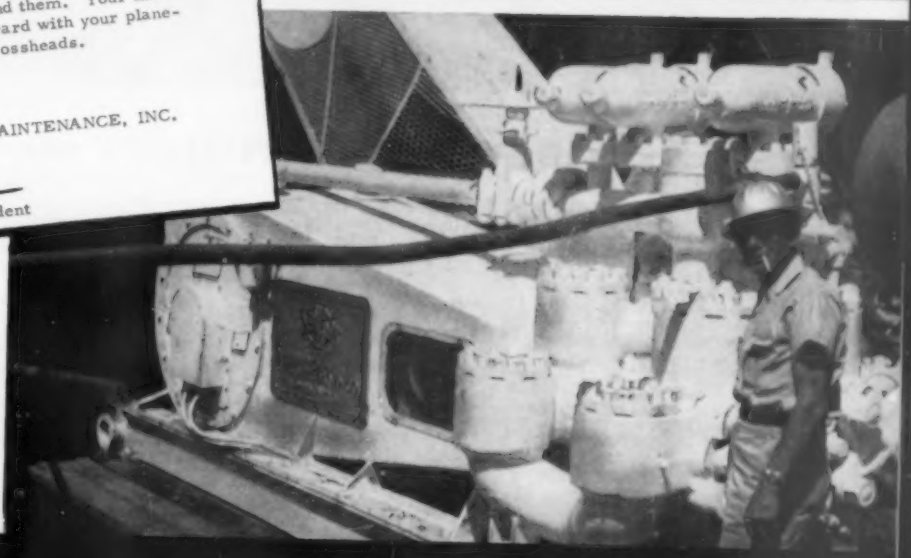
We are now operating Wheland HP-18000, HP-14000, and HP-16000 Pumps and are glad to recommend them. Your new HP-16000 Pump design is a great step forward with your planetary gears, big bearings and cylindrical crossheads.

Yours very truly,

OIL PRODUCTION MAINTENANCE, INC.

J. K. Butler

J. K. Butler, President



**Wheland HP-16000 Planetary Pump owned by Oil Production Maintenance, Inc., on location in the Gulf Coast area.**

# WHELAND

ROTARY DRILLING MACHINERY

**THE WHELAND COMPANY**
CHATTANOOGA, TENNESSEE, U.S.A.

**DRAW WORKS • SLUSH PUMPS • ROTARIES**
**CROWN BLOCKS • TRAVELING BLOCKS • SWIVELS**

DOMESTIC DISTRIBUTORS: INDUSTRIAL SUPPLY COMPANY, INC.—Main Office: Wichita Falls, Texas • HOUSTON OIL FIELD MATERIAL COMPANY, INC.—Main Office: Houston, Texas.

EXPORT DISTRIBUTORS: LUCEY EXPORT CORPORATION—233 Broadway, New York 7, New York—Broad Street House, London, E. C. 2, England.

## OVER 9" OF PENETRATION IN HARD BEREA SANDSTONE

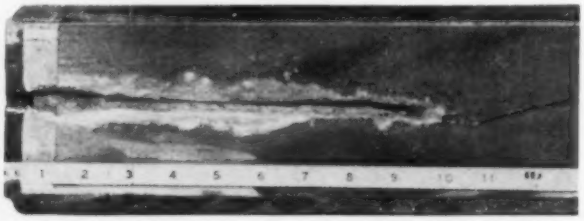
Two more powerful, deeper penetrating Glass Jet Units are now available from McCullough. They are improved Super Casing Glass Jets carrying 25 and 35 grams respectively and are run in flexible Steel Strip Carriers to perforate 4" OD casing and larger.

In tests conducted in standard Berea Sandstone targets, penetration for each size was greater than ever before achieved – more than 9" in these very hard targets and with excellent well flow index.

McCullough Glass Jets are the only expendable jet charges that are relatively junk free. When fired they disintegrate into a harmless powder of silicon and lime. No carrots are formed. Fragments of junk, usually associated with other expendable jet perforators, are eliminated. The Steel Strip Carrier is removed from the well after the gun is fired on the electric wire line.

For deeper penetration – peak production – use improved McCullough Super Casing Glass Jets on your next job.

The 25-gram Super Casing Glass Jet is available in 3¼" OD and 3¾" OD gun diameters. The 35-gram size is furnished in 4" OD and 5" OD diameters. Perforators may be any length required to perforate several intervals on one run in the well. This is accomplished by leaving blank sections in the length of carrier where perforating is not required.



Standard Berea Sandstone target perforated by 25-gram improved Super Casing Glass Jet at ½" clearance. Average penetration of a series of tests – 9.312". Average entrance hole size – 0.375". Pressure rating – 20,000 psi. Temperature rating – 300°F.

**McCullough**
TOOL COMPANY
Los Angeles • Houston • Edmonton
Cable Address: MACTOOL



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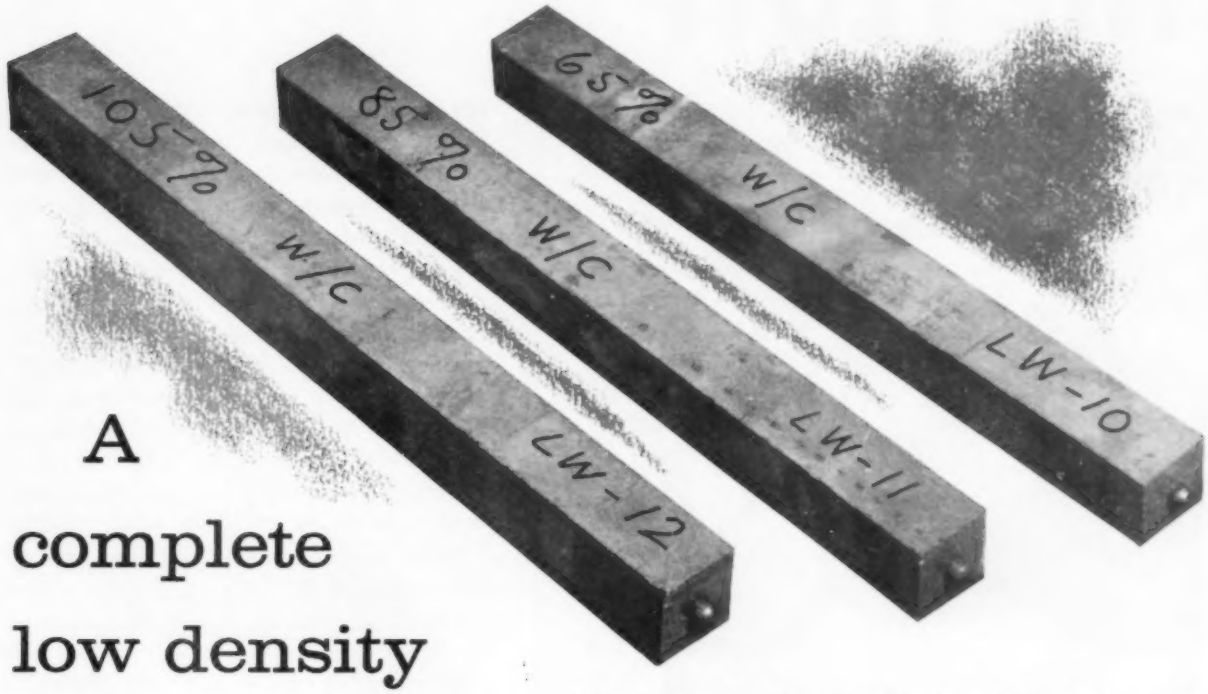
ADVERTISED PRODUCTS, SEE READER SERVICE CARD

# Trinity LITE-WATE




A complete low density cement that is

# SULPHATE RESISTANT

Shown above are three unretouched photos of test bars produced from TRINITY LITE-WATE neat slurry that were immersed in a 5% sodium sulfate–5% sodium chloride solution for a period of more than one year. These bars are completely sound and show no expansion.

In the range of lightweight cement slurries, TRINITY LITE-WATE produces a slurry which is:

1. Sulfate resistant for lasting casing protection.
2. Remains impervious to migrating fluids.
3. Light enough to circulate.
4. Strong enough for any casing seat.
5. Strong enough to permit hydraulic fracturing.
6. Easy to mix, easy to pump.

For TRINITY LITE-WATE cement call your service company.

For complete Laboratory Data call your local Trinity Representative or write Dallas Office, P. O. Box 2698 or phone RIverside 2-8111.

75 lb. Dry Volume per cubic foot

TRINITY

PORTLAND CEMENT DIVISION

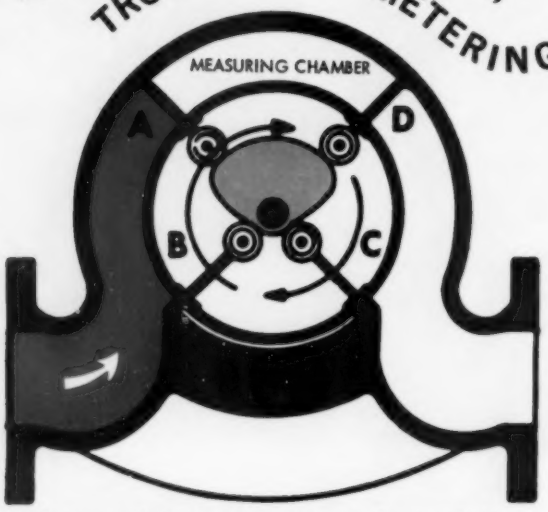
GENERAL PORTLAND CEMENT COMPANY

GPCC

DALLAS·FT.WORTH·HOUSTON

# FOLLOW THE FLOW

## THAT LEADS TO ACCURATE, TROUBLE-FREE METERING

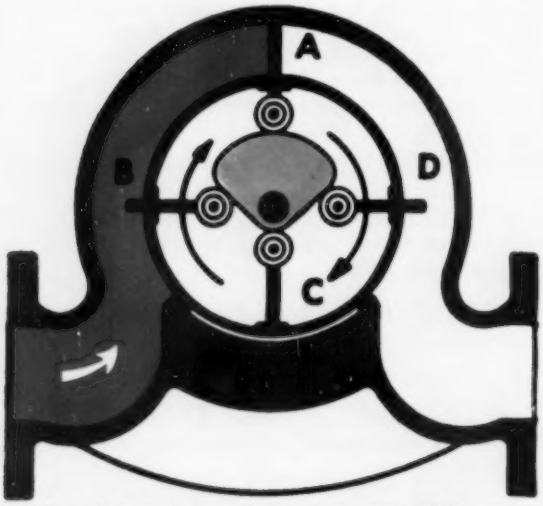



Unmeasured liquid (dark green) is shown entering meter. Rotor and vanes are turning clockwise. Vanes A and D are fully extended, forming the measuring chamber. Vanes B and C retracted.

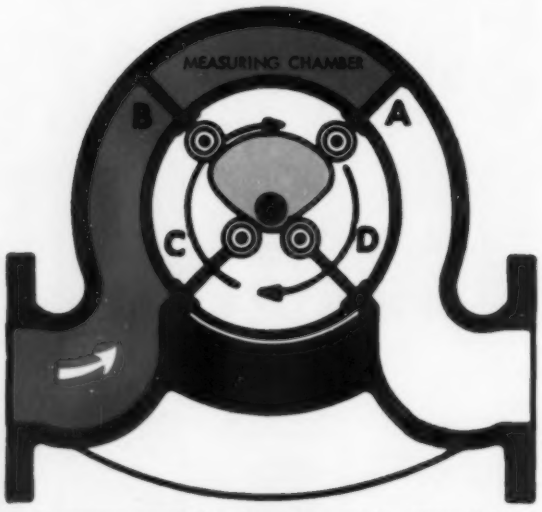
*It's a matter of principle* — the A. O. Smith Rotary Positive Displacement principle that results in the *simplest*, most *accurate* and *trouble-free* metering ever devised for petroleum products.

Let's take a look inside a typical Smith-Erie meter. What we see in these diagrams is a mechanism consisting of a free-running balanced rotor which carries four symmetrical vanes. As the rotor revolves on ball bearings around a central shaft, the vanes are positioned — moving with the fluid stream and dividing it into precisely measured segments of equal and exact volume.

Looks *simple* and it is. Frictional resistance is almost completely eliminated. Flow pattern is smooth and offers no resistance to streamlined flow. *Accuracy?* It's the most! Records show a consistent ability to retain accuracy for the longest periods of time, throughout the greatest flow range. And it's virtually *trouble-free*. Low pressure drop saves power and prolongs service




The rotor and vanes have made one-eighth revolution. Vane A is fully extended; Vane D is being drawn back; Vane C is fully recessed; Vane B is being extended.




A quarter revolution has been made. Vane A is still fully extended and Vane B is now fully moved out. An exact and known volume of new liquid is now in the measuring chamber.



FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

life. Rotor speeds are held within conservative limits to assure long life and freedom from wear.

With such a simple, positive operating mechanism, it's no wonder Smith-Erie meters can be depended upon to provide uniformly high accuracy — day after day and year after year — under the most exacting service requirements.

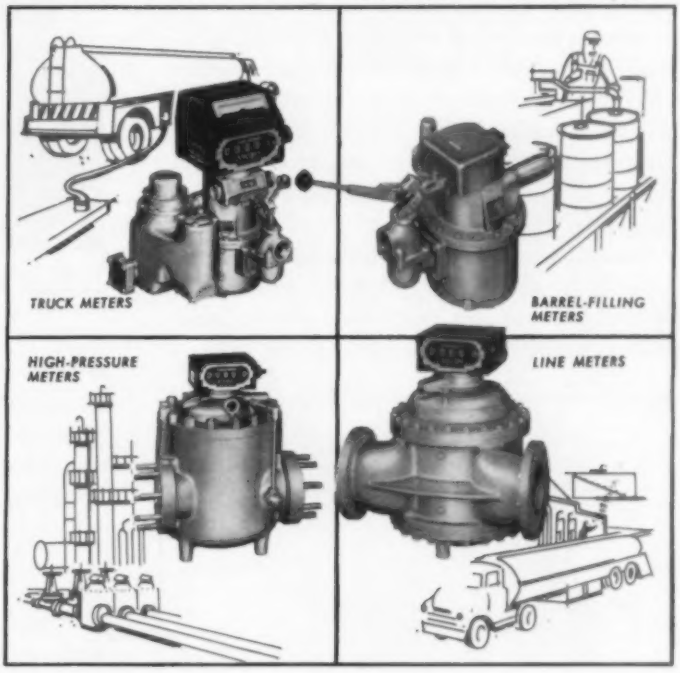
*Through research* ... *a better way*

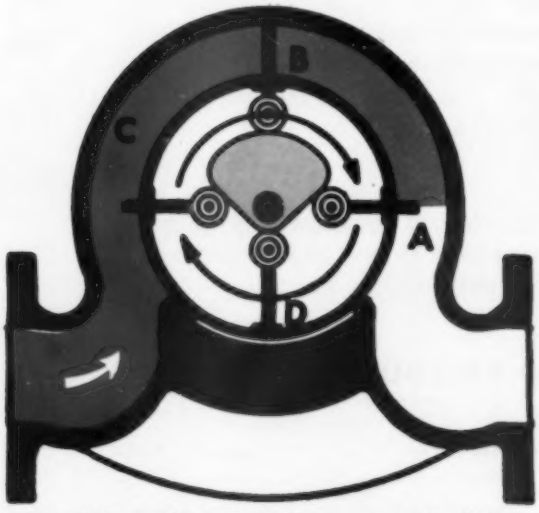
**A.O.Smith**
CORPORATION

**Smith-Erie Division**

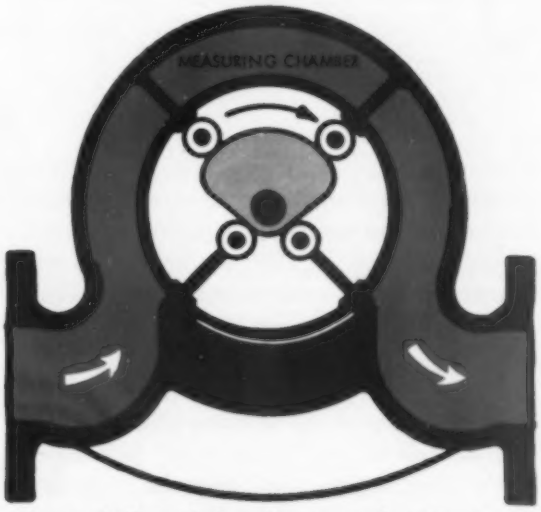
Factory: 1602 Wagner Ave., Erie, Pennsylvania. Offices: Atlanta 5, Ga.; Chicago 3, Ill.; Houston 2, Texas; Los Angeles 22, Calif.; New York 17, N.Y.; Newark, Calif.; Tulsa, Okla. Canada: Toronto 12, Vancouver 1. A. O. Smith INTERNATIONAL S.A., Milwaukee 1, Wis., U.S.A.

## Rotary Positive Displacement Principle Is the Heart of All Smith-Erie Meters




One-eighth revolution later, the measured liquid is moving out. A second measuring chamber is beginning to form between Vanes C and B. Vane A is being drawn back.



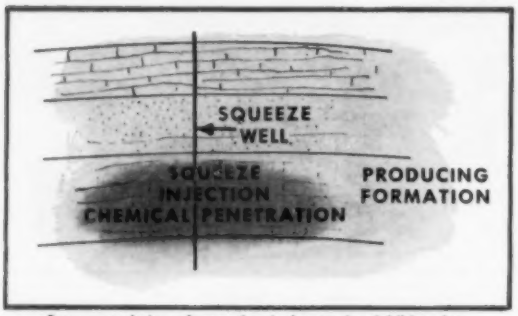

In one-half revolution, two measuring chambers have formed and the third is forming. This cycle is repeated as long as liquid flows.

# Visco Squeeze Treatment Chemicals Designed to Fit Varying Well Conditions

## Corrosion Control Lasts, Costs Less with New Visco Formulas, Methods

Squeeze treatment in producing wells continues to grow in importance as an economical, long-term method of obtaining effective corrosion control. It is simply the pressure injection of corrosion inhibitor chemical into the producing formation, from which it is released in approximate proportion to produced fluid volume over a period of time—anywhere from two to sixteen months.

Visco has found squeeze treating of sufficient interest to producers to justify development of specialized chemicals and techniques to permit most effective use of the method.




Squeeze technique forces chemical corrosion inhibitor into formation around well bottom. Chemical is carried back with produced fluid. The excellent film persistency of Visco squeeze treating chemicals assures long-lasting, low-cost well protection.

### Effects of Formation

Producing formation composition, porosity permeability and position can have an important bearing on the success of squeeze treatment corrosion control . . . They are important considerations in the development of special Visco formulas for this purpose.

### Determining Chemical Type

As with any operation affecting producing formations, experience is the most dependable guide. Chances are great that the conditions you have in your area have been closely paralleled by other Visco squeeze treating experience. Further, Visco Formulas such as

Visco's J. P. Stanton, Product Manager for Corrosion Control Chemicals, discusses factors considered important in assuring effective squeeze treatment.

S-1390X, 956, S-1339X, were developed to broaden the effectiveness of corrosion control with squeeze treatment, and so are a big help in pinpointing the best chemical and method to apply to specific well characteristics.

### Field Experience

Squeeze treating can offer some substantial cost and time advantages for effective corrosion control in many types of producing wells . . . BUT, probably more than any other treating method, squeeze treatment demands skill and experience, as well as effective chemicals, to assure success. No one is better equipped than Visco . . . *we* firmly believe no one else can do as well for you.

### Help, Now

Visco action toward being useful in your activities is as close as your phone—and nearly as quick as picking it up. Your move.

**VISCO PRODUCTS COMPANY**
Incorporated
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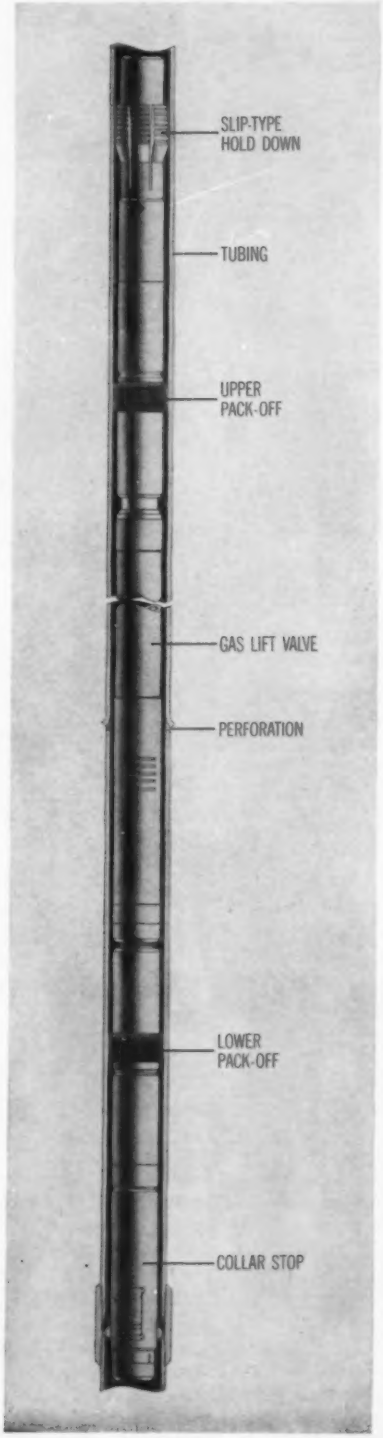
# OTIS PRODUCTION NEWS

*Volume II, Number 3* **Otis Engineering Corporation • Dallas** *Production Equipment and Services*

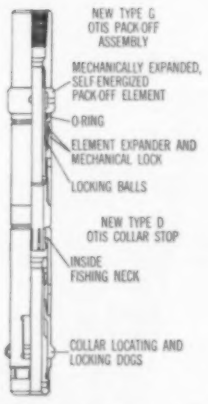




## Cost-Conscious Producing Companies Endorse Otis All Wire Line Technique Of Converting Wells to Gas Lift

CORPUS CHRISTI—Eliminate the cost of a pulling unit to round-trip tubing when converting a well to gas lift and you can save an impressive amount of money per well. That's what several of the major producing companies in this area discovered when they started using the new Otis "All-Wire-Line" Gas Lift Conversion Technique.

A spokesman for one of these majors recently stated that his company is most enthusiastic about the technique — especially for water locations — because "(1) it's faster, (2) it's less expensive, (3) it's every bit as efficient as other types of installations they have made, and (4) it eliminates the risk of damage to the producing formation from contamination by mud and/or water in the annulus." Another company reported a savings of $60,000 in converting three, readily accessible, land locations.

As an example of how the technique can reduce the cost of a conversion, take a look at the following case history: A 6800-foot well located in approximately three feet of water in the Copano Bay Field ceased to flow naturally and was scheduled to be put on gas lift. In making plans to have the work done, it was discovered the approach canal had filled with silt and sand, which meant an expensive dredging operation would be necessary before a barge-mounted workover unit could be moved onto location; cost of a workover unit would be $1400 per day, and the annulus was loaded with old drilling fluid. Estimated conversion costs were mounting fast. A conference with the Otis Gas Lift Specialist in the area convinced the operator he should try a Type CG Otis Pack-Off Gas Lift Valve installation.


NEW TYPE G OTIS PACK-OFF ASSEMBLY
MECHANICALLY EXPANDED, SELF-ENERGIZED PACK-OFF ELEMENT
O-RING
ELEMENT EXPANDER AND MECHANICAL LOCK
LOCKING BALLS
NEW TYPE D OTIS COLLAR STOP
INSIDE FISHING NECK
COLLAR LOCATING AND LOCKING DOGS

**Straight through, full opening bore of pack-offs, collar stop, and gas lift valve permits maximum production with minimum turbulence.**

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After setting a circulating plug in the tubing at the spot indicated for the lowermost valve, perforating and circulating mud from the annulus, it took the trained Otis Wire Line Specialist only 15½ hours of wire line time to perforate and install five concentric Type C Gas Lift Valves between Type G Otis Pack-Off Assemblies and have the well ready to be put back on production. Eight months following the conversion, the well was still making its allowable in an economical and efficient manner. And to attest to the reliability of the new Type G Otis Pack-Off Assemblies, the well was being produced from the lower-most valve.

Otis Gas Lift and Completion Specialists are interested in helping you find a way to complete and produce your wells in the most efficient manner. The experience these men have accrued throughout the years is yours to draw from when faced with any down well completion or production flow control problem. Use the knowledge these men have to offer and you will find you'll be spending your production dollars more efficiently. For more information on the Type CG Otis Pack-Off Gas Lift Valve, call the Otis office nearest you or write Otis, Dept. 3-W, Box 35206, Dallas 35, Texas. You'll find your Otis specialists ready to help you — anxious to serve you.

**OTIS**

**Engineering Corporation**

**General Offices:**

**6812 Denton Drive • Dallas, Texas**

# TUBINGLESS COMPLETIONS

*Baker has developed a complete new line of products for completions using tubing as small-diameter casing.*

The picture shows some of these new products. The complete line very nearly parallels the entire Baker line of conventional-size products.

The line includes: Primary Cementing Equipment (shoes, collars, centralizers, scratchers, turbulizers); Remedial and Stimulation Tools (treating packers; both retrievable and drillable bridge plugs); Production Tools (retrievable and drillable production packers; casing pump packers, tubing anchors).

Many of these new Baker Products are not yet available in quantity, nor in all areas.

Tubingless Completions are becoming more numerous. Our own engineering and development programs continue as Baker keeps alert to the trends—ready to provide the practical and dependable new tools that will further improve tubingless completion methods and techniques.

**WE INVITE YOUR INQUIRIES**
Please ask your Baker Man for Technical Bulletin 378, or write to Baker Oil Tools, Inc., Box 2274, Terminal Annex, Los Angeles 54, California

**BAKER**

**BAKER OIL TOOLS, INC.** / HOUSTON / LOS ANGELES / NEW YORK

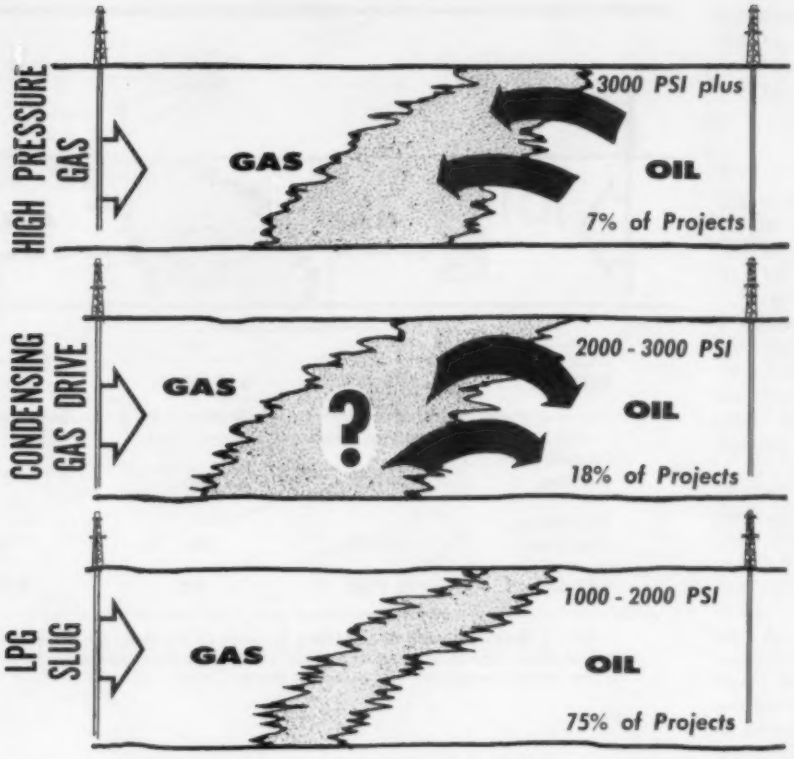



FIG. 1. **Three basic processes of** miscible phase displacement in current field operation and pressure ranges for each. Percentages of each process in relation to all projects discussed in literature are shown.

***Where are we going with . . .***

# MISCIBLE DISPLACEMENT?

**A. B. DYES,** *Supervising Research Engineer, The Atlantic Refining Company, Dallas, Texas*

**A general analysis of the various miscible processes and some observations of projects in operation provide an insight into what some of the obstacles are and where we are headed.**

THE PETROLEUM INDUSTRY is making a major effort to verify miscible displacement as an improved oil recovery process. This effort is at a peak and between 40 and 50 projects are in actual field operation. Performance results are beginning to come in, and with these results also comes the question of success or failure. Have we proved a new and valuable oil recovery method, or are these processes too expensive and too unpredictable?

The answers to such final and major questions cannot be fully reached yet. Many of the better projects are still in an early period of their producing life. Performances to date, however, are pointing up some of the critical problems in designing and exploiting miscible displacement. A number of these projects have been described in some detail in the literature and in discussions. What is the experience to date? How many of what types of miscible displacement processes are there in operation? What are some of the major cost differences? What are some of the attractive features of each miscible drive process? From what we have already learned, where do we go from here with miscible displacement?

## Where Are We Today?

We can look ahead by examining where we are today and what has been our experience. Based on published reports and papers, there appear to be in existence between 40 and 50 miscible drive projects in actual operation. In the past 1½ years, the author has examined 13 of these projects. Of this number, some are yet to be completed and observations of these uncompleted projects can only be based upon early performance.

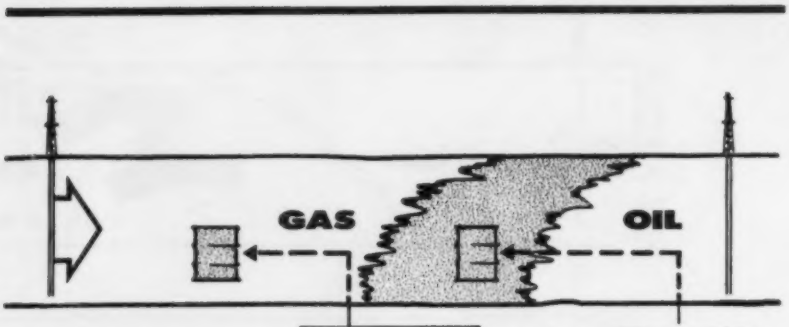
Of the 13 projects studied, seven appear to be successful. Success in this instance may be defined as the maintenance of a miscible drive mechanism

and the movement of substantial amounts of oil by this process. At this early stage in the application of miscible displacement, such behavior should constitute success.

### Failures and Why

Six of the 13 projects studied are failures and one should also expect some of the remaining projects to fail. A principal cause of failure is the lack of maintaining adequate pressure. These are certain minimum pressures required for each type of miscible process. If the necessary pressure condition is not maintained there is no chance whatsoever for success. Adequate pressure can be achieved through proper design and operation.

A second cause of failure, particularly for the LPG slug process, has been the use of too small a miscible slug. It should be pointed out that the slug size for an actual reservoir was not know prior to the field trials. Laboratory studies had measured only the slug sizes for relatively homogeneous porous systems. The very small idealized slug sizes of 0.5 to 1.0% of the hydrocarbon pore volume shown to be needed by laboratory experiment were expected to be increased several fold for application to non-homogeneous reservoirs.




| MISCIBLE PROCESS | PLANT COSTS $/Bbl/Day Injection Rate | GAS COSTS $/Reservoir Bbl Space Filled | MISCIBLE ZONE COSTS $/Reservoir Bbl Space Filled |
|---|---|---|---|
| High-Pressure Gas | $53.00 | 28¢ | 14¢ |
| Condensing Gas Drive | $20.00 | 15¢ | 60¢ |
| LPG Slug | $ 7.50 | 9¢ | $1.70 |

FIG. 2. **Some prime costs factors** for each of the three processes in field use. These figures are qualitative rather than quantitative but do indicate the relative magnitude for each cost factor.

### Slug Size

Field results are showing that an LPG slug size of 1% of the hydrocarbon pore volume within the sweep area is not enough. A 2% slug appears to be short lived. The successful LPG slug projects are using slug sizes in the range of 4 to 7%. Again, success at the present means that miscible displacement was maintained to move significant quantities of oil. It should be emphasized that there is no unique slug size to fit all reservoirs. Each reservoir must be studied in detail and a slug size chosen which is thought to best suit the requirements of a particular reservoir.

A third reason for failure arises from the extreme heterogeneity of some reservoirs. Miscible processes are not "last resort procedures." They should not be tried in fields that appear unsuited for other injection processes. As a matter of fact, miscible drives are somewhat temperamental processes and should be applied to those reservoirs which are even better than required for conventional operations.

**Another reason for failure** in a few instances appears to stem from unsatisfactory well control where the injected fluids to achieve miscible displacement did not enter the formation properly and escaped into non-pay sections. Checking injection wells before and during the placement of the miscible zone material is desirable to detect and repair any leaks so that the desired amount of slug can be placed in the pay section.

### Miscible Methods Today

There are three methods now in operation for developing miscible displacement with a gas, as shown in Fig. 1. The first is the high-pressure gas process. Field separator gas is injected at a relatively high pressure, generally above 3000 psi into a reservoir containing a high gravity crude, rich in intermediates and under saturated with respect to the injected gas. The gas and oil are immiscible on first contact. As the gas passes over the oil or with the passage of time, the intermediates come out of the oil and pass into the gas phase to build a zone of miscible displacement. The development of a miscible zone in this manner is a rugged feature of this process. The reservoir is filled with an oil which can generate its own zone of miscible displacement when in contact with a gas.

The second process, the condensing gas drive (enriched gas) can develop miscible displacement at lower pressures than those required for the high-pressure gas procedure. Gas containing a high concentration of intermediates, perhaps 50% propane and 50% methane, is injected into the reservoir. Propane goes out of the gas and into solution with the oil. This oil enrichment continues until miscible displacement is achieved. How much rich gas to inject is a major unanswered question for this process. There is no field evidence available at this writing to indicate the amount required. Economics generally will not permit the reservoir to be completely filled with rich gas.

Designers of projects employing the condensing gas drive apparently contemplate the use of very large slugs of rich gas. On theoretical grounds, the slug size for the patented condensing gas drive process is expected to be 4 to 8 times the slug size for the miscible LPG slug process. Field evidence is coming in on the LPG process indicating slug sizes of 4 to 7%. If the expected increase over that of the LPG process holds, the condensing gas drive will probably require a rich gas slug of 15 to 30% of the hydrocarbon pore volume. The enriched gas is costly and at normal prices for the enriching intermediate, such projects may not be attractive in comparison to less costly injection procedures.

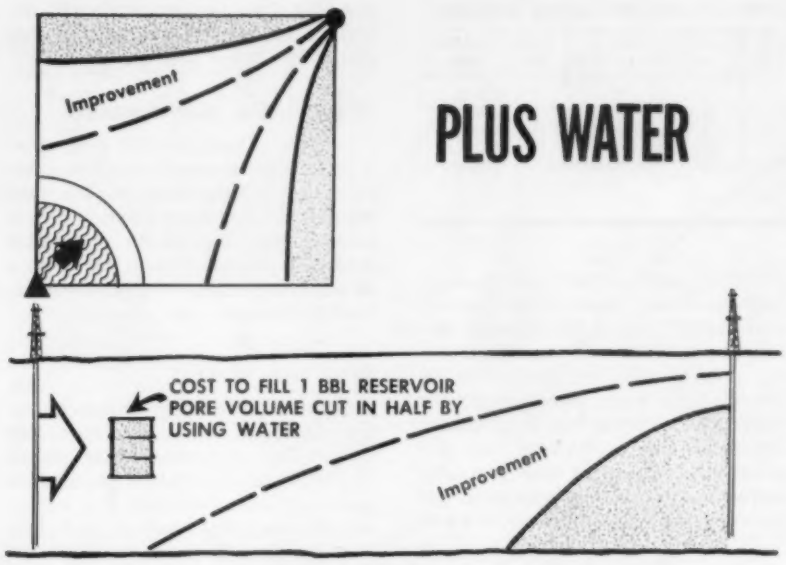



FIG. 3. **Benefits by adding water** to a miscible project include increased sweep efficiency as well as reducing cost of injected fluids.

The third process is the "miscible LPG slug." The principal advantages of this procedure lie in its ability to achieve miscible displacement at low pressures. If propane is employed, this pressure can be around 1200 psi. With butane somewhat higher pressures are required, around 1800 psi. These pressures vary slightly dependent upon temperatures.

The LPG slug process is the most popular to date. Of the projects reported in the literature, approximately 75% are classified as LPG slug projects, 18% are condensing gas drives and 7% are high pressure gas operations.

## MAJOR COST FACTORS

The cost of generating the miscible zones of displacement for all these processes is the first cost item to be examined. Relative costs are shown in Fig. 2. On a cost per bbl of pore volume filled by the miscible zone, the high-pressure gas process is lowest. All of the enriching agents flow out of the reservoir oil into the gas. The miscible zone will contain approximately 50% gas. The cost of this amount of gas will be around 14 cents per reservoir barrel occupied by the miscible zone.

With the condensing gas drive, operating in a pressure region of around 2000 to 3000 psi, the cost of filling a reservoir barrel with enriched gas (50% methane, 50% propane) will be around 60 cents. In the LPG slug projects, with normal prices for LPG, the cost will be approximately $1.70 per bbl.

On the basis of the cost per barrel filled in the miscible zone, one would prefer to use the high-pressure gas process first, the condensing gas drive second and the LPG process third.

### Behind the Miscible Zone

Another major factor in the overall economics of the miscible process is the cost of filling a reservoir barrel of space in the region behind the miscible zone. The cost of this is primarily reflected in the value of the gas used and the initial investment in an injection plant. The high pressure gas procedures require the most gas and is consequently the most expensive. Considering a gas value of 20 cents per MCF available at 600 psi, a reservoir barrel of gas costs around 28 cents for the high-pressure gas process, 15 cents for the condensing gas drive and 9 cents for the lower pressure LPG slug operation.

### Relative Plant Costs

The initial investment in plants also differs between the three processes. For each barrel-per-day injection rate, the high-pressure gas process requires a plant investment of around $53 compared to $20 for the condensing gas drive and $7.50 for the LPG slug project (gas available at 600 psi). The difference in this major cost item between the processes is only illustrative. A detailed economic analysis of all costs and revenue is necessary in deciding between the three processes for a specific reservoir.

### What the Costs Show

These major cost items do suggest one or two interesting points. For example, consider a reservoir in the high-pressure gas region, with an injection rate of 5000 reservoir bbl per day. A choice must be made between operating at 3500 psi with the high-pressure gas process or permitting the pressure to fall and operate with a condensing gas drive.

Savings in compression costs alone for a lower pressure condensing gas drive operation would buy a rich gas slug of 1%, although this slug size is inadequate for the process to succeed. Lower gas requirements of this lower pressure process could provide a saving in current expenses (for a 15-year project) sufficient to buy a slug of rich gas of 10% of the hydrocarbon per volume. This size is probably too small for the successful application of a condensing gas drive to an entire reservoir. As mentioned earlier, the slug sizes for the LPG project are 4 to 7% and the requirements for the condensing gas procedure is expected to be several times this amount.

For average field prices paid for enriching components, the high-pressure gas process would probably be favored when there is a choice between programs. Whenever the reservoir pressure is not high enough or the oil light enough for the high-pressure gas process, the choice would be between the condensing gas drive and the LPG slug to attain miscible displacement.

The lower pressures, lower gas costs and the probable smaller slug size of the LPG miscible slug process favor its use over that of the condensing gas drive at present. However, the use of large LPG slug sizes in the successful range of 4 to 7% does not lead to any unusually attractive economics except under special situations of low LPG cost and high waterflood cost.

In dealing with heterogeneous reservoirs, it is desirable to direct efforts to extend the high-pressure gas mechan-

TABLE 1 RELATIVE RATING OF MISCIBLE DRIVE FEATURES

| TYPE MISCIBLE DRIVE | MOBILITY RATIO | AREAL SWEEP | GRAVITY OVER RUN | FINGERING | STRATIFICATION | SLUG SIZE | PRESSURE |
|---|---|---|---|---|---|---|---|
| *High-Pressure Gas* | 10 | 1 | 1 | 1 | 1 | 1 | 3 |
| *Condensing Gas* | 50 | 2 | 2 | 2 | 2 | 3 | 2 |
| *LPG Slug* | 100 | 3 | 3 | 2 | 3 | 2 | 1 |

ism for achieving miscible displacement to lower pressures. The characteristic of this process in which the reservoir already is filled with a material capable of generating its own miscible zone results in a high chance of success.

The use of carbon dioxide gas can lower the pressure required down to about 1500 psi for some crudes, primarily those rich in intermediates. It is desirable to develop this type process for lean crudes and for lower pressures.

## Reservoir Response to Miscible Processes

A comparison between the ways to generate miscible displacement in terms of some of the reservoir features that affect performance will serve to illustrate the relative advantages of each. The schematic diagrams of the processes in Fig. 1 illustrate the effect of some important aspects of reservoir performance under miscible drives. Elongation of the zone of miscible displacement results from permeability stratification, fingering of the gas under adverse mobility ratios, and gas overrun under the influence of gravity. The dilution of the zone of miscible displacement as one miscible fluid displaces another in a porous media also influences the slug size.

## Relative Ratings of Process Features

In addition to these features, areal sweep and pressures are also considered in Table 1. This comparison considers that the high-pressure gas process is employed in the 3000 to 4000 psi range, the condensing gas drive in the 2000 to 3000 psi range and the LPG projects in the 1000 to 2000 psi range.

## Mobility Ratios

Under these conditions, the mobility ratio of these projects (mobility of gas region divided by mobility of oil region) will be around 10, 50, and 100 for the three processes of high-pressure gas, condensing gas drive and LPG slug respectively. These mobility ratios are unfavorable to field performance. Some reservoir features in combination with mobility ratios in excess of one lead to poor performances. The higher the mobility ratio the poorer the recovery. Table I lists several aspects of performance and makes first, second and third choices between the processes in obtaining the most favorable performance. The high-pressure gas procedure is favored in all respects, except for the pressure required. The condensing gas drive would be favored over the LPG slug except in the important and determining smaller slug size and in lower pressure level.


ABOUT THE AUTHOR

**A. B. Dyes** is a supervising research engineer in The Atlantic Refining Company's crude oil production research laboratory, Dallas, Texas. He joined the company as a junior engineer in 1945 after obtaining a

BS degree in chemical enginering from Georgia Tech. The 15 years with Atlantic have been directed to the development of methods of reservoir analysis and the application of reservoir engineering principles to field operations. He has made and directed the engineering studies for the application of the miscible drives to the University Block 31, University Block 9, and Slaughter fields of West Texas and the Neale field in Louisiana. He is inventor of a process using slugs of carbon dioxide in miscible displacement and the process of simultaneous use of water in any miscible process. He is a member of the Society of Petroleum Engineers of AIME and the American Petroleum Institute.


## What is the Best Process?

Is there a best miscible process or is there any best aspect for all miscible procedures? Regardless of the type miscible displacement employed there is one feature that should be included in all field projects. That is the addition of water to the injected gas stream behind the miscible zone.

## Why Use Water?

There are several good reasons for the addition of water. The first reason is the improvement in areal sweep which can be obatined. If the miscible zone is followed only by gas, a poor overall sweep will result. This is illustarted in Fig. 3 for a quarter of a 5-spot element. Without water, performance is unfavorable for all patterns since wells are arranged in such a manner that it is not possible to attain either linear or radial flow.

**A real sweep improvement.** If water is added to the injected gas stream immediately behind the miscible zone, the areal sweep for miscible displacement can be enlarged. In addition, any small area not swept miscibly will be ultimately swept by the water and gas mixture.

**Vertical sweep enlarged.** The second important reason for adding water is the improvement which can be obtained in the vertical sweep of a stratified reservoir as shown in Fig. 3. Such reservoirs show very poor performance if only gas is used. The addition of water lowers the mobility ratio in the swept region and dampens the influence of permeability variations. The result is an improved sweep at breakthrough and reduced gas cycling requirements after breakthrough.

**Gas Costs Reduced.** A third reason for adding water to the injection stream is to lower the cost of filling a barrel of reservoir space behind the miscible zone. Each barrel of water used, costing 1 to 2 cents, substitutes for a barrel of gas costing 9 to 28 cents. In addition, the size of the gas injection plant is cut almost in half. This is a major reduction in the initial investment required since the water plant will cost only a fraction of that portion of the gas injection plant which it replaces. These advantages are in addition to an improvement in oil recovery performances.

Water is being used in three of the four miscible projects operated by The Atlantic Refining Company. The one not employing water has a very low permeability reservoir. This is one condition which limits the addition of water because of the low fluid injectivity resulting from low reservoir permeabilities.

Benefits to oil recovery by the addition of water to the injected gas stream are shown in Fig. 4. This is a calculated performance for a badly stratified reservoir. The application of miscible displacement using only gas would result in a poor performance and the recovery of only 40% of the in-place oil. The addition of water to the program would reduce the mobility in the swept region, improve the recovery at gas breakthrough, maintain the oil producing rate, reduce the gas cycling requirements and the size of the gas plant. By adding water, calculated in-place oil recovery increases to 80%. Such calculations serve to illustrate the effect of adding water to a project when all other aspects are held constant.

Many of the projects in operation today involve miscible displacement followed only by gas injection. In view of the poor areal and vertical sweep efficiency by gas alone, results of some of these projects cannot be expected to be much better than waterflooding. However, many of the projects in operation do indicate that miscible displacement has been maintained and that substantial quantities of oil have been moved. Water could be added to these projects to insure a much higher recovery than that expected by either a miscible gas or by waterflooding alone.

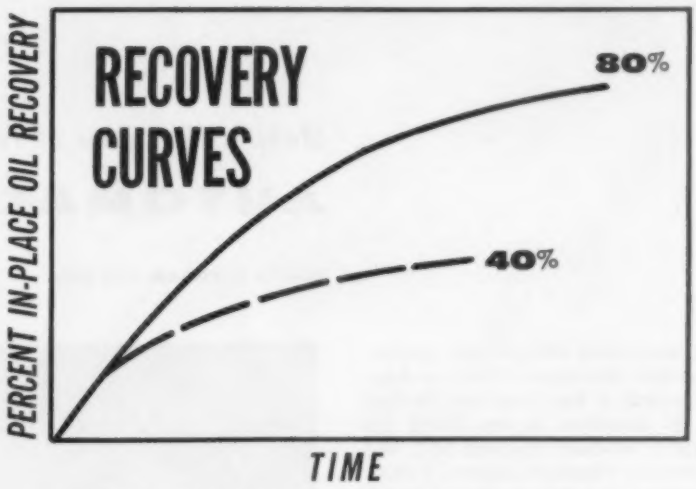



FIG. 4. **Calculated recovery factors** for a hypothetical miscible drive project where formation is highly stratified in permeability. Solid line represents recovery when water is added to injected fluids; dashed line is recovery without water.

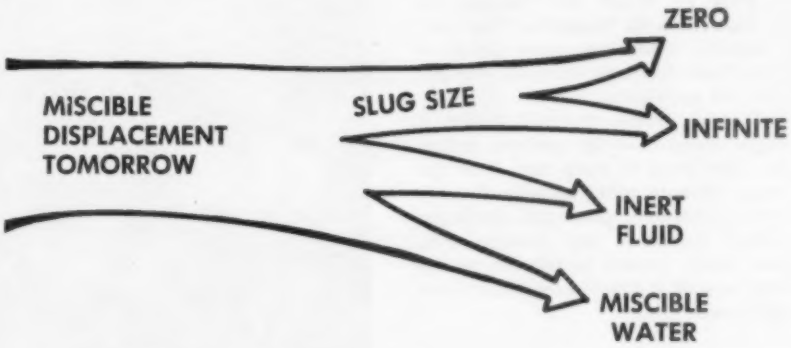



FIG. 5. **Direction of miscible drives tomorrow** will probably go in several directions. Research of miscible water as the displacement fluid shows promise as well as inert fluids, such as flue gas. Slug size changes are also in the offing; either towards zero or infinite.

### What of Tomorrow's Improvements?

Perhaps the first improvement indicated will be in the LPG slug process. Developments might go in two directions: (1) reduce the slug size to zero, or (2) increase it to infinity. In the high-pressure gas process, the slug size is zero, for the reservoir generates its own miscible zone. This manner of miscible zone generation must be developed for a wider range of reservoir conditions, particularly to include the lean oil and low pressure reservoirs. Some of the possible means to accomplish this are already under study. The use of carbon dioxide and other gases holds some promise.

When increasing the slug size to infinity by injecting rich gas continuously, it is necessary that the cost per reservoir barrel filled be reduced to about 30 cents. If this cost reduction can be accomplished, rich gas injection will be favored over the LPG slug process.

More use of inert fluids to follow the miscible zone is in order. Water and flue gas will gain prominence. The trend toward greater use of water in conjunction with a miscible gas is already evident. Flue gas generators are available now and their use will lower the cost to manufacture this type of gas.

### Miscible Water?

The ultimate miscible displacement process would indicate the use of water only to follow the miscible zone since it is the cheapest fluid to fill reservoir space and yields relatively high sweep efficiencies. Such an approach is already under study in one field pilot test.

Alcohol is used as the miscible slug material. However, the high cost of alcohol as slug material plus the probable large slug size required suggests that this type of miscible program may not be operational for several years and may require additional research modifications. The problems of miscible displacement with only water and a miscible or near miscible agent, however, are nearing a solution, and this may be the ideal oil recovery process of tomorrow. ★ ★ ★

*Mobil's first year of remote-controlling . . .*

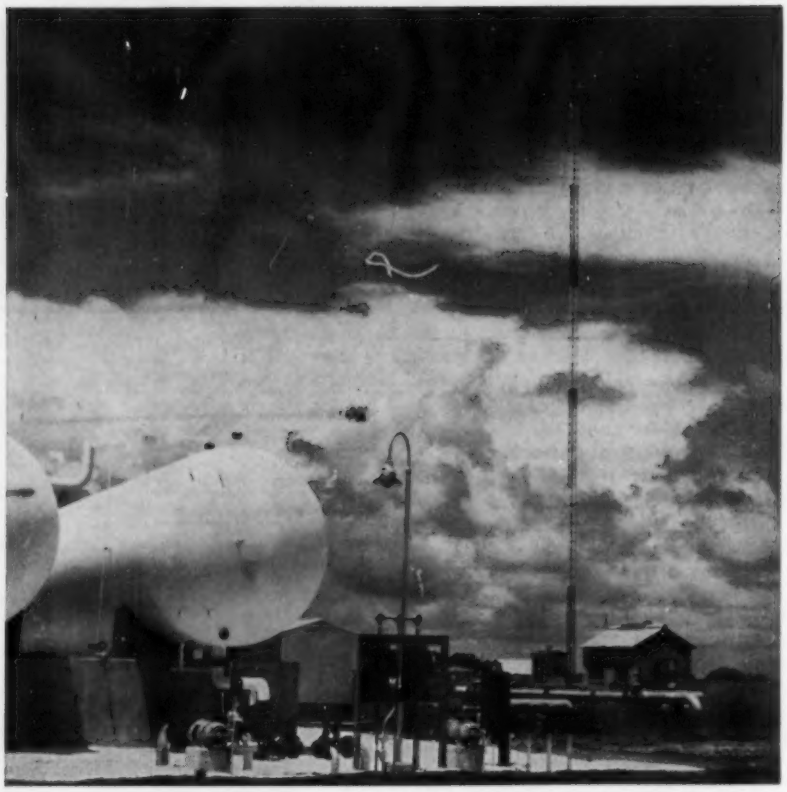
# AUTOMATED OFFSHORE

WALTER A. HOGAN, Field Editor

**First automated offshore gas production system that transmits data to shore and records it has completed its first year of operation on the Mobil Oil Company offshore Platform 10-L and at Cameron Meadows onshore station. The system has already allowed Mobil to produce gas more efficiently, the company stated.**

**The installation operates production equipment on seven gas wells flowing some 6.5 MMCF per day located about 14 miles southwest of Sabine, Texas. It was constructed during the summer of 1959 by Mobil Oil Company in conjunction with Magnolia Pipe Line Company, whose engineers acted as consultants for installation of the microwave equipment.**

**The pushbutton system enables a single operator at the onshore station 26 miles away to open and close the seven offshore wells individually, adjust gas volumes produced, check on critical pressures and temperatures, and locate trouble in specific equipment should it develop on the offshore platform.**



Microwave tower stands like steel needle against the sky at Mobil gas-distillate separation and recovery station on Louisiana coast.

Mobil reports highly satisfactory results achieved from the basic concept of the automatic and remote-controlled operation at its Block 10-L, High Island facility. They have succeeded in eliminating the cost of providing quarters and maintaining personnel offshore at the production platform, which would have been necessary under more conventional methods of operating. After the initial period of start-up, Mobil found that it was able to stay with its original plan of scheduling routine service trips to the platform only once each week. Unscheduled service trips to the platform have been practically nil. The operation has proved itself to the extent that this method is now being studied for application in other Mobil offshore operations.

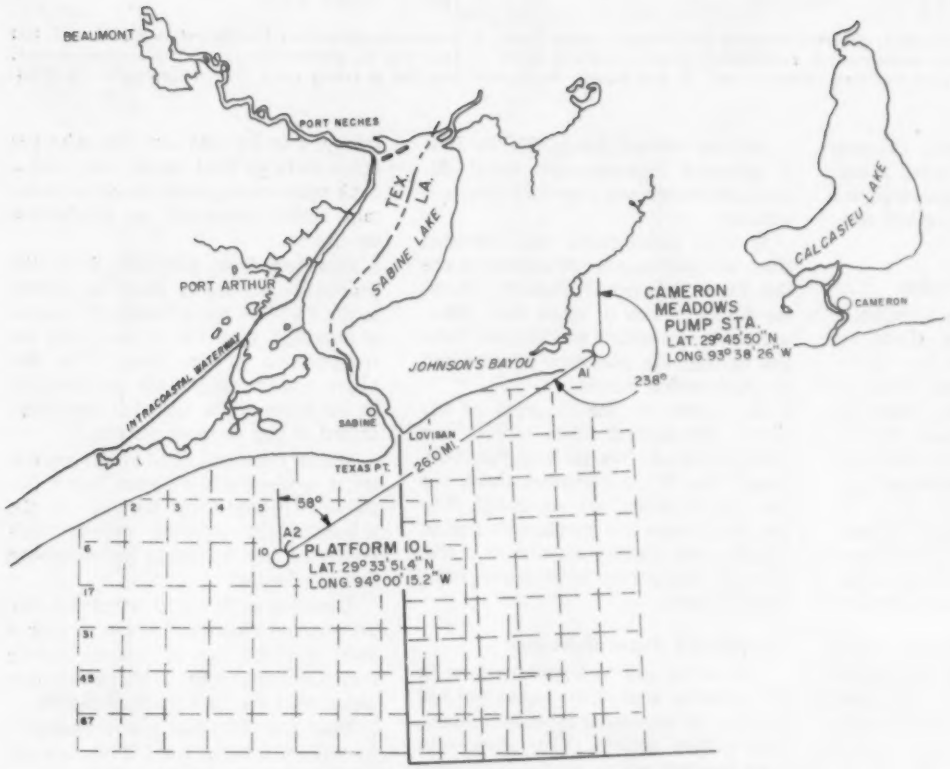
At the Block 10L facility, the microwave equipment has functioned very reliably and has given little trouble. The various sensing devices, instruments and controls which function in conjunction with the microwave have also given satisfactory service.

**Mechanical functioning** of the producing equipment and operating scheme has been generally satisfactory with only the minor sort of troubles that can be expected in a new operation of this nature.

One bit of difficulty hinged around the fact that at least some degree of dehydration is necessary in order that the combined gas and distillate stream can be moved to the onshore separation station with hydrate difficulties in the pipe line. Mobil successfully dries the gas on the platform, but apparently the distillate stream carries traces of moisture with it which is given up to the gas phase when the streams are recombining leaving the platform. The company is now in the process of installing a glycol-type gas dehydrator at the onshore facility to eliminate this difficulty.

**Gas delivery from the platform** is made through a 10-in. pipeline, and production rate from the platform has been fairly consistent at approximately 6.5 MMcf per day of gas and 18 bpd of distillate. Production equipment is designed to handle 15 MMcf per day. Wells have a high open flow potential

# GAS PLATFORM




**Map shows 14-miles covered in controlling offshore Platform 10-L, the gas-production installation, from the onshore Cameron Meadows Pump Station.**

and gas-oil ratio, and they produce little water.

Surface shut-in pressures are from 1920 psia to 7126 psia.

**Main design feature** of the installation was an attempt to keep the installation as simple as possible, providing only necessary data and performing essential functions. It also was planned with dual equipment performing the same function to provide a stand-by operating system to allow uninterrupted performance should mechanical trouble develop.

### Microwave Equipment

The microwave system operates in the 2000 mc range, with the Cameron Meadows onshore station operating at 1855 mc using a 260 ft guyed tower and a 10 ft parabolic antennae, and the offshore equipment operating at 1895 mc.

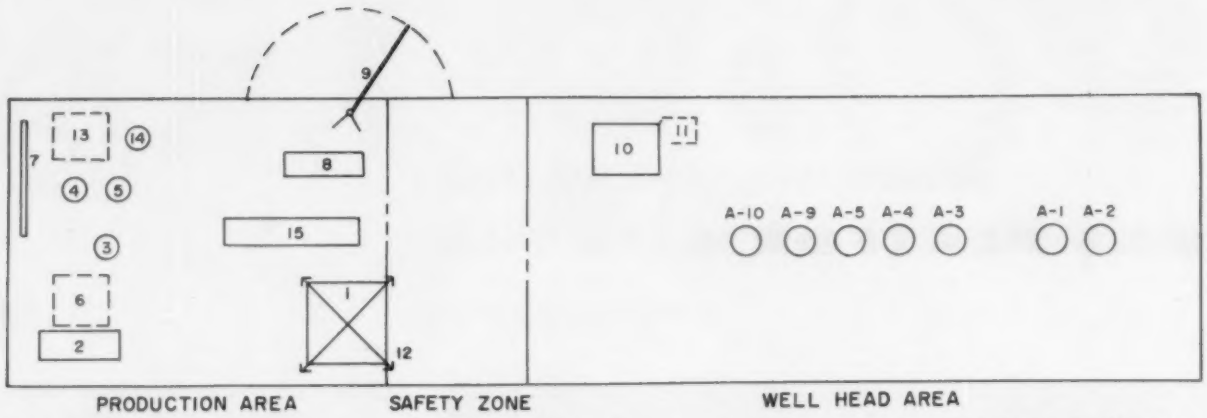
The system has a 24-voice channel capacity, but only the service channel is used. Twelve tone or telemetering channels are used to give pressure functions and flow information; and two control channels are used, primarily to switch wells.

In line with the concept of this installation, the microwave system is designed for 100% hot-standby electronic equipment with automatic switch-over in event of component failure.

### Production Platform Equipment

Mounted on production platform are 7 full-stream orifice meters; 3 MM Btu per hour line heater; 15 MMcf per day spherical production separator; 8 MMcf per day test separator with internal metering chamber; 50 bbl oil per day distillate metering chamber; 15 MMcf per day glycol dehydration unit; distillation skimmer tank; dual sale orifice meters; and a pressure relief system. (See platform diagram).

Two 35 kw generators driven by gas engines furnish power for platform equipment. One of these units is an auxiliary or standby generator.




**Equipment layout on platform includes 1, generator-microwave building, 2, meter house; 3, production separator; 4, dehydration absorber; 5, test separator; 6, meter area; 7, sales meter runs; 8, dehydration reconcentrator; 9, hoist; 10, fog horn; 11, platform landing; 12, microwave derrick; 13, distillate skimmer; 14, distillate metering chamber; and 15, line heater. Production area has a safety zone that is explosion-proofed.**

Other auxiliary equipment consists of "local readout" instruments, a microwave antenna tower, foghorn signal unit, four-ton hoist, lifesaving and similar safety devices.

### Supervisory Control Point

Besides being the first platform automatically controlled from shore by microwave, it is the first for Mobil that can measure the total distillate produced by an automatic metering chamber and allocate it back to individual wells on a basis of individual well full-stream measurements and corresponding tests.

From the Cameron Central Separator Control facilities, an onshore operator selects wells to put on production controls gas flow rate, and shuts in wells.

A strip chart records each well's flow rate and can check on the operating status of various production and microwave equipment by trouble-indicating alarm lamps. All these control functions, records, and alarms are incorporated in an onshore control panel, the Supervisory Control Mimic Panel. (See diagram). This diagram shows the entire operation of the platform installation. All of the remote devices are controlled by this panel and data are recorded on charts inset into its face.

The microwave equipment transmits coded electrical impulses between the panel control and remote platform installation to effect the supervisory control of remote platform equipment.

These codes are similar to those used in the familiar dial telephone system in that each code consists of a group of impulses. These are varied to transmit the information necessary for the equipment to perform a particular function.

A full-stream meter measures each wellhead stream at wellhead pressure. Total distillate produced is metered by a positive volume meter (PVM). It is a spherical high-pressure vessel designed to meter and register a constant volume.

Special permission was obtained from the state regulatory agency to use this Lease Automatic Custody Transfer device in lieu of stock tank measurements of distillate production. Total gas leaving the platform is measured by dual orifice meters.

As shown on the diagram of the panel, gas and distillate stream are recombined and flow through the 10-in. leased line. When it reaches shore, the gas and distillate are separated. The gas then enters the purchaser's line at which point custody transfer is made. The distillate is stored in atmospheric storage tanks.

### Simplified Flow Scheme

The seven gas well streams flow to the metering area where individual full streams are measured by conventional-type orifice meters. They flow into three headers which are the high pressure, 2500 psig; low pressure, 1700 psig; and the test header.

The high and low pressure header lines combine at the line heater where the pressure is reduced to 1000 psig, the operating pressure of the production separator and dehydrator absorber. This full stream flows to the production separator, where gas, distillate, and water are separated.

**Gas dehydrator.** Gas from the production separator flows to the glycol dehydrator absorber. Water vapor in the gas is absorbed by lean glycol, which thus becomes rich glycol and is circulated to the glycol dehydration reconcentrator unit, or still, where the water is stripped out of it. The lean glycol produced is recirculated back to the absorber.

The dry gas streams out of the absorber is divided and measured as sales gas or for fuel use. The sales gas flows through dual meter runs and a back pressure regulator is set to maintain system pressure on production equipment.

**Distillate flow.** Distillate from the production separator flows by gravity to the PVM on the subdeck, its volume is recorded, and it is dumped into the transmission line to shore. The distillate and sales gas are commingled in the transmission line, but are reseparated at the onshore station.

Water from the production separator is metered and dumped into a distillate skimmer tank located on the subdeck. This volume settling tank separates any entrained hydrocarbons from the water.

Distillate in this tank overflows into an internal chamber, where it trips a level switch, and is automatically pumped into an inlet to the production separator by a high pressure pump.

**Fuel gas.** The fuel gas is measured by an orifice meter and it flows through the line heater fuel coil, where pressure is reduced to 150-psig, and it is scrubbed of any possible moisture by a mist eliminator.

A power cylinder operated by this gas activates seven wellhead electropneumatic shut-in valves as a part of the supervisory system.

From the scrubber, fuel gas makes a pass through glycol dehydration reconcentrator unit fuel coil and its pressure is reduced to three levels. They are instrument gas, 20-psig; line heater and reconcentrator unit fuel gas, 20-psig; and generator engine fuel, 8 ounces.

**Test separator.** This device is used in conjunction with well testing and full stream measurement coefficient. Well stream being tested flows from the test header through the line heater to the separator.

After passing through the separator, it is metered by a conventional orifice meter, recombined with the production separator gas flowing to the absorber. Distillate is measured by an internal metering chamber and is dumped into the inlet line to the production separator. Water is metered and dumped to the skimmer tank.

**Pressure relief system.** Each vessel and pressure is connected to a pressure relief system. It is relieved through a 6-in. line and flare stack located 130 ft west of the platform. The entire production facilities are relieved through this system whenever the platform is shut in.

## Operation of Equipment

**Wellheads.** Each Christmas tree on the seven gas wells is fitted with electro-pneumatic-operated plug valves bolted between the tree's wing valve and positive flow choke. The electro-pneumatic operated plug valve is normally operated remotely from shore through the control unit, although it can be operated manually just like all the other remote-controlled equipment.

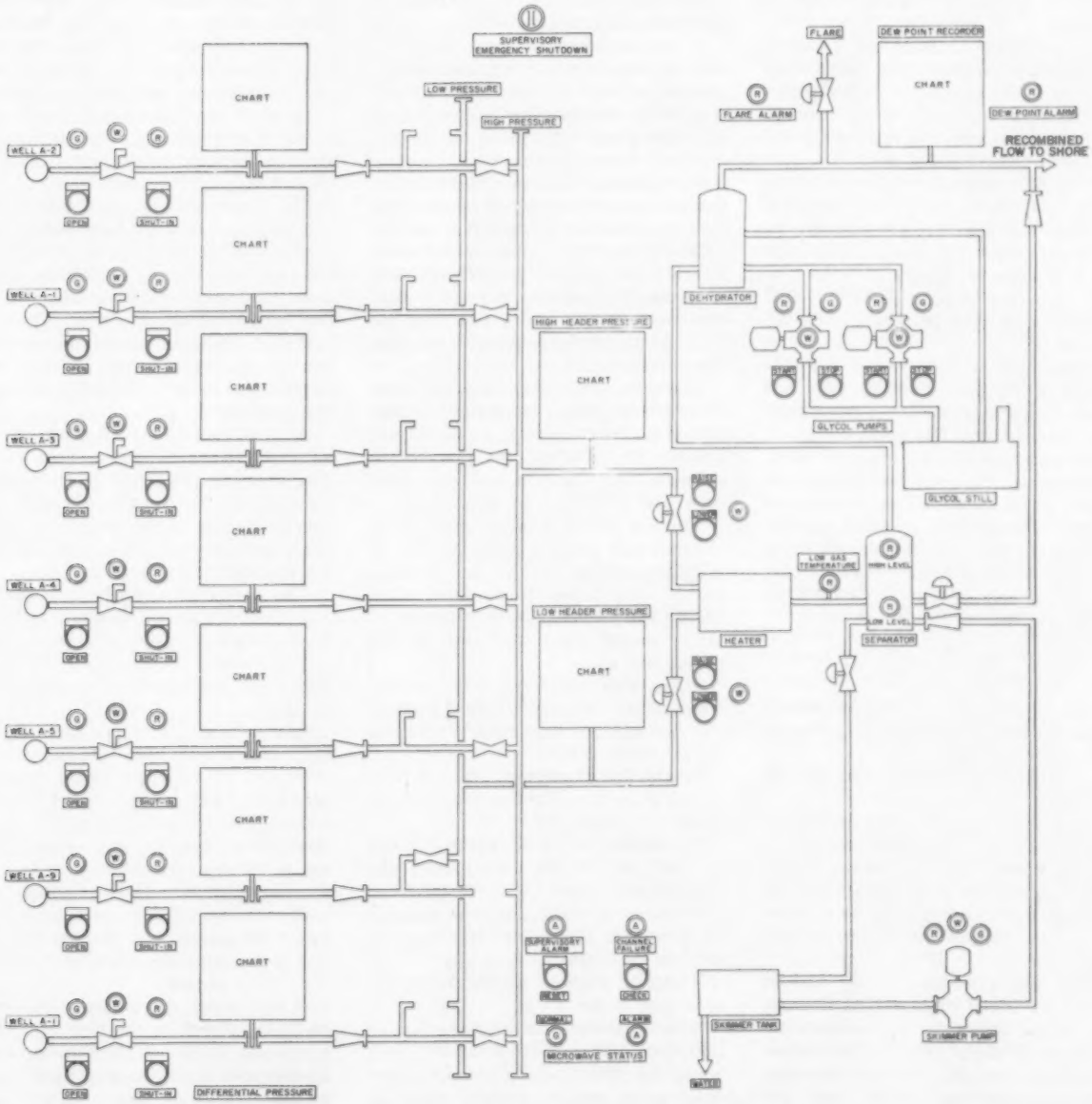
Thus individual wells can be put on or taken off production.

Should an electrical failure occur, power gas acting on the power cylinder will close the plug valve and shut in the well.

Each wellhead is also fitted with a positive-flow choke. This is sized to allow only minimum pressure drop. The chokes are not only for control, but also serve as a safety device should the bottom-hole choke or electro-pneumatic valve fail to shut in the well should a flow line break.

**Well flow lines.** The seven well flow lines are located beneath the main deck along the platform's firewalk from the wellheads to the metering area. Each 2-in. flow line has a low pressure shut-in switch tied into the well plug-valve circuit to shut in an affected well should a flow line break occur. The switches are connected to the flow line through meter-run manifolds.

Each flow line is fitted with a sec-




**Supervisory control mimic panel diagram shows operating layout of the platform, control pushbuttons, and charts which record data.**

ond positive-flow choke before the stream is metered. Proper sizing of the chokes is quite critical, as they control the maximum production rate of each well. Choke size must be determined in the field, depending on productivity and characteristics of each corresponding well.

**Full-stream meter runs.** Conventional orifice meter runs measure the full stream flow rate, which includes a commingled stream of gas, distillate, and water.

When flow rates are calculated, chart readings are handled as if they were a gas stream only. A full-scale separation test must be run on each well stream to determine the ratio between gas, distillate, and water. These tests are run semi-annually, or whenever a positive choke or orifice plate is changed.

In addition, differential pressure transmitters measure the differential pressure drop across the orifice plate. Instruments transmit these readings through the microwave unit to the supervisory control panel onshore.

**Well flow headers.** Wells A-1, A-2, A-3, A-4, A-5, and A-10 produce through the high pressure header at 2500 psi. Well A-9 produces through the low pressure header at 1700 psi. The pressures depend on the wells' flow rates and the particular wells on stream.

Piston-type check valves are installed in the flow lines between the meter runs and headers to prevent back flow should a flow line break occur.

Pressure transmitters relay the static pressures of high and low headers to shore, where they are continuously recorded. The onshore operator can determine the flow rate of any well using the differential and static pressure that the full stream meters are recording.

Here is the formula:

$$Q = C(h_w)(P_f)\ (.024)$$

Mcf per day

Where C — Orifice meter coefficient as found in meter book for given meter run and plate size

$h_w$ — Differential pressure across orifice plate

$P_f$ — Static pressure on meter run which is same as header pressure.

**Line heater.** The line heater is designed to heat the three header streams through three sets of coils at a maximum flow rate of 30 MMcf gas per day.

The high-pressure header stream makes an initial preheat pass through the heater, where the gas temperature is raised to about 100 F. This stream then flows through a remote-controlled pneumatic-operated choke and the pressure is dropped to about 1000 psi.

The low pressure header stream is choked through a second remote-controlled pneumatic-operated choke and the pressure is reduced to about 1000 psi. The two streams combine at this point and pass through the second set of heater coils.

The onshore operator can change the setting of the choke, and thus flow rate and header pressure, by simply pushing the raise or lower button on the supervisory control panel onshore. The amount of flow rate change brought about by this control change is recorded by the header pressure and meter differential pressure.

The 1000 psi outlet stream's temperature is continuously sensed, controlled, and recorded by a temperature controller. This instrument directly operates the fuel gas supply to the line heater. The outlet gas stream temperature is recorded at about 80 F.

A low-temperature alarm switch is also incorporated into this instrument. The alarm is set to react at 65 F, and should this temperature be reached, a red lamp alarm will light up on the supervisory control panel.

Two pressure shut-in switches sense the gas outlet stream's pressure. The high pressure shut-in switch is set for 1300 psi, and the low pressure shut-in switch is set for 100 psi. When either set pressure is reached, the entire platform will shut in and a trip must be made to the platform before operation can be resumed.

The well test stream utilizes the third set of heater coils. The inlet test header stream is choked through a manual adjustable choke where the pressure is reduced. The different well test flow rates are controlled by this choke.

The line heater is fitted with a flash arrestor and positive draft control as a safety device against gas ignition flashes and flame blowout by high winds. Should the pilot light go out, a safety shutoff valve will shut in the heater fuel gas.

Upon high water-bath temperature, temperature override controller shuts the fuel gas off. This control point is set at about 180 F.

**Production separator.** The full well stream flows from the line heater to the production separator.

The water level is maintained in the separator by a liquid level control and a diaphragm dump valve. Water from the bottom of the separator is metered by a positive type meter and dumped into the distillate skimmer tank.

Distillate flows by gravity out of the separator to the PVM.

The production separator is equipped with a high separator level shutdown switch and a low separator level alarm switch. Should water or distillate fail to flow out of the separator for any reason, the high fluid level will trip the high separator level shutdown switch and shut in all of the wells.

Onshore, the high separator level alarm lamp and all the status lamps will indicate that the wells are shut in. When the high level condition is corrected, the proper button is pushed to put the well back on production.

Should the water dump valve fail to close and the separator drain dry of any liquid, the low level alarm switch will trip, lighting the low separator level alarm lamp on the supervisory control panel.

Should this situation occur, the platform must be shut in manually by the operator onshore.

**Dehydration unit.** The gas stream from the separator flows to the dehydration unit absorber. Gas enters the bottom of the absorber and bubbles upwardly through the glycol on the trays. Upon leaving the top trap, the gas flows over a coil which contains warm, lean triethylene glycol. An efficient mist eliminator at the top of the absorber reduces carryover of the entrained liquid glycol particles.

The tower operates as the lean incoming glycol solution flows out of the cooling coil at the top onto the uppermost tray and then to succeeding trays down the tower until it accumulates in the bottom of the absorber. Then it contains water that has been absorbed out of the vapor phase of the gas stream, and hydrocarbons in solution and suspension.

A liquid control and diaphram dump valve maintains the rich glycol level. The absorber continuously discharges glycol from the absorber through the heat exchanger in the surge tank, unit filter, and distillate flash tank into the gas distillate skimmer column.

The gas-distillate flash tank allows any dissolved gas or distillate to flash from the glycol. Any entrained or dissolved distillate is separated and withdrawn in the gas-distillate skimmer column.

The rich glycol enters the packed still column and flows into the reconcentrator, or reboiler, where heating removes all but a small percent of the water. Then the hot, lean glycol overflows into the surge tank beneath the reconcentrator, where heat is lost to the incoming rich glycol through the heat exchanger. A high pressure pump forces the glycol back into the cooling coil in the top of the absorber to repeat the drying process.

Water vapor driven from the wet, incoming glycol by the high temperature being carried in the reboiler rises up the packed column where entrained or vaporous glycol may cool, coalesce, and run back down into the reboiler.

A gas sweep prevents air from con-

tacting glycol in the reboiler and surge tank by bleeding through a small quantity of low pressure gas into the surge tank. Gas sweep discharge is piped into the still column immediately below the condenser, reducing the possibility of condensing water putting a vacuum on the still thus causing air to enter.

A reboiler temperature of 350 F to 375 F is maintained to remove water from the triethylene glycol. The reboiler firebox is fitted with a flash arrestor and draft control element for additional safety.

There are two 5 hp glycol pumps, one operating, and one standby. Either electrically operated pump can be started or stopped from shore. Lamps on the supervisory control panel indicate which pump is running.

Dry gas leaving the absorber must have a moisture content not exceeding 6-lb $H_2O$ per MMscf to meet contract conditions.

**Distillate metering chamber.** Distillate from the production separator flows by gravity into the PVM distillate metering chamber which is located on the subdeck. The PVM vessel meters a constant volume of distillate upon each filling and dumping cycle.

The PVM is normally in the fill position, as the fill and topping valve are open and the dump valve is closed. When the topping valve is open, gas may pass from the chamber back to the separator gas overhead through the equalizing line. The upper float actuates the closing of the fill and topping valves through a delay relay.

**Distillate skimmer tank.** Water production from the production and test separators dump into the distillate skimmer tank located on the subdeck.

The skimmer tank has internal overflow chamber to handle any distillate that may be dumped into the tank with the water. When the overflow chamber fills it is pumped into the production separator inlet line.

Water separated overflows from the tank into a siphon leg. Gas vents from the tank through a low pressure vent stack set to hold back two ounces back pressure on the tank.

**Sales gas.** Dry gas from the dehydration unit's absorber flows through dual orifice meter runs. Settlement with the state regulatory agency for the total gas leaving platform is based on dual sales meter run measurements plus a calculated flash gas volume as determined from the total distillate production.

Downstream of the sales meter runs is a back pressure regulator set to hold a pressure of about 1000 psi on the production separator and dehydration absorber. Gas enters the transmission line to shore at this point.

Offshore platform end of the transmission line is fitted with a pig trap located on the subdeck. Pressure is maintained on the transmission line through back pressure regulators located onshore.

A dew point tester hygrometer monitors the gas stream moisture content at this point. A flow rate of 74.5 cc per min gas must be set to pass through the hygrometer sampler. This rate is set by a built-in flow regulator and indicated by a graduated flow meter. An alarm lamp is set to light should the dew point reach the maximum acceptable level.

**Fuel gas.** Dry gas from dehydrator absorber is metered through an orifice meter and make a pass through the fuel coil in the line heater. Dual pressure regulators drop gas pressure from 1000 psi to 140 psi. A gas scrubber traps any liquids present in the fuel gas.

The fuel gas is then piped to the wellheads and connected to the electropneumatic valve operator. Fuel gas from the scrubber passes through the reconcentrator reboiler fuel coil.

A fuel gas manifold reduces the pressure three ways, gas engine fuel gas, eight ounces; line heater and glycol reboiler fuel, 20 psi; and instrument supply gas, 50 psi.

**Test separator.** When testing wells and determining full stream meter coefficients, the test separator unit is used. Each well can be produced and tested through this separator, and it has an internal metering chamber and counter for distillate measurement.

Gas is separated and metered by an orifice meter run. A back-pressure regulator maintains test separator pressure. Water production is metered by a positive type meter and dumped to the distillate skimmer tank; and oil from the separator portion of the test separator is dumped into the internal metering chamber.

A shrinkage tester is provided to determine the flash factor.

**Gas engine-driven generators.** Offshore, two 35-kw generators furnish the electrical power for the microwave and supervisory control units, glycol pumps, distillate skimmer tank pump, cathodic rectifier unit, lights, and stiffleg hoist.

Each gas engine is directly coupled to a 50 kva generator, 40 kw at 80% power factor, 3 phase, 60 cycle, and 120/208 volt at 1200 rpm.

One unit runs continuously on the line, the second unit is on automatic standby duty. Should the operating unit shut down because of low oil pressure, low water pressure, low vacuum pressure, high water temperature, or overspeed condition, the standby unit will automatically start up and come on the line.


### Acknowledgment

Material used in compiling this article was provided by personnel of Mobil Oil Company and Magnolia Pipeline Company, a wholly-owned subsidiary. ★ ★ ★


## Ultrasonic Pipe Inspection

A new drill pipe inspection system developed by International Inspection, Inc., of Houston, Texas employs the basic principle of pulse-echo immersed ultrasonics.

This "silent sound" detects flaws and then charts record them into a permanent log of wall thickness throughout the body of the pipe. Record reveals minute fatique cracks, corrosion pitting, wear inclusions and other hidden flaws throughout the body of the pipe.

Several scientific and engineering developments were necessary before the system could be used for tubular goods inspection in the oil field.

Probably the most important of these was the development of focused transducers which allow a hairline width of ultrasound to be beamed through the cross section of tubular goods. Focusing effect is important because much smaller flaws can be defined and a more accurate thickness measurement is possible.

Second development was a coupler. Since ultrasound will not travel through air, water is used as a transmission medium between the crystal transducer and drill pipe or material being inspected.

Third factor is a combination electronic thickness gage and flaw marker which records ultrasonic echos on the log.

# SPECIAL TECHNIQUES CUT CORROSION COSTS

D. R. FINCHER, *Research Chemical Engineer, Tidewater Oil Company, Houston, Texas*

**Effective corrosion inhibition at substantial savings has resulted from three relatively new methods known as (1) inhibitor squeeze, (2) tubing displacement and (3) slug, circulate and park.**

**CORROSION COSTS** the petroleum industry millions of dollars every year. This problem is certainly not new and many thousands of dollars have been spent in developing inhibitors and techniques to combat corrosion. The actual destruction of equipment by corrosion accounts for only part of the final bill. Much of the final cost comes from interruption of programs, deferred or lost production, and maintenance and repairs.

As producing companies strive to reduce their capital costs, new completion and production techniques have been developed which necessitate vast improvements in corrosion control. For example, the relatively new tubingless and permanent completions demand almost absolute control of corrosion problems in order to be successful.

The past few years have brought about impressive improvements in inhibitors and techniques. Better placement of inhibitors and better inhibitor mechanisms have been especially welcomed. Reduced application costs and procedures have reduced the problem of deferred production. This can be an important factor in areas of marginal production, but is less serious where production is already limited by allowables.

Another important result of improved inhibitors is their reduced tendency to form emulsions. This is especially desirable in automatic crude-handling installations.

Based on a talk by the author before the North Texas Section of the National Association of Corrosion Engineers, Dallas, November 14, 1960.

## SPECIAL INHIBITION TECHNIQUES

Three relatively new techniques worthy of special consideration have been extensively field tested and are being used rather effectively. They are known as (1) inhibitor squeeze method, (2) tubing displacement method, and (3) slug, circulate, and park method.

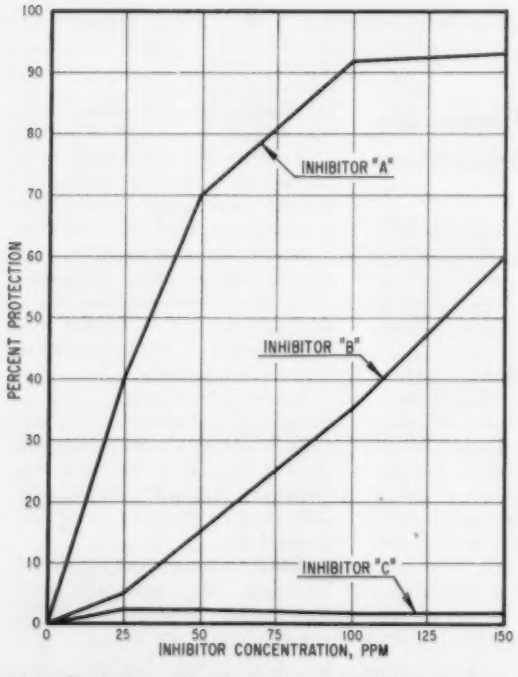



FIG. 1. **Typical results of continuous inhibitor exposure tests.** In this case, Inhibitor "A" would be considered satisfactory.

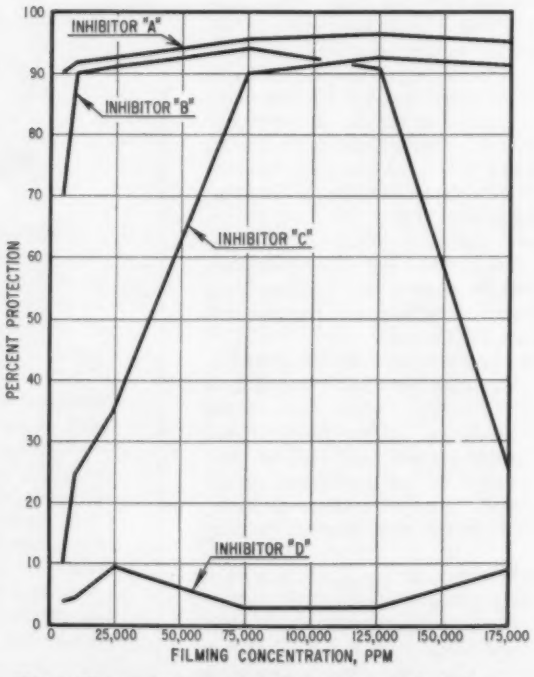



FIG. 2. **Film persistency tests** of inhibitors might look something like these curves. Inhibitor "A" shows the ability to form and keep a persistent film.

### Inhibitor Squeeze

The inhibitor squeeze technique consists simply of pumping a slug of concentrated inhibitor mixture down the tubing under sufficient pressure to squeeze the mixture into the producing formation. The subsequent action of the inhibitor is not absolutely certain: some say that the inhibitor dribbles back into the well as it is produced, while others maintain that the process simply establishes a persistent protective film on the tubing walls.

Likewise, there are no fast rules regarding inhibitor concentrations or carrying fluids. Normally, one drum of inhibitor in 7 to 10 bbl of either a refined hydrocarbon, such as diesel oil, or a lease crude or lease condensate can be used. Use of lease hydrocarbon is preferable where possible.

In a normal operation, the inhibitor slug is followed into the formation with a flush of approximately 40 bbl of fluid.

Experience has shown that, when properly performed, the inhibitor squeeze technique will provide as much as a year's protection with one placement of inhibitor in the formation.

### Tubing Displacement

The tubing displacement technique involves pumping a slug of inhibitor mixture down the tubing to the face of the formation with no attempt being made to pump it into the formation. This procedure is often the result of encountering excessive pressures during a proposed inhibitor squeeze treatment. If the well will take the inhibitor mixture, usually it should be pumped into the formation.

Some operators are reluctant to use the inhibitor squeeze method or the tubing displacement method, fearing that the possibility of permanently damaging the well is great. It is possible to damage a well with these techniques, but not necessarily if proper precautions are taken. The same danger exists in an acid job or when killing a well. The treatment can be designed to minimize any danger of fracturing the well or pumping loose the packer. Many problems arising from the application of these techniques are a result of lack of knowledge of the mechanical limits of the equipment in the hole on the part of the supervisor of the treatment.

### Slug, Circulate and Park

An inhibition technique especially adaptable to pumping wells is known as the slug, circulate, and park method. The technique can be used in wells which have a working fluid level and in which tubing can be run with no packer.

A rather large slug of inhibitor is introduced into the tubing-casing annulus where it mixes with or floats on the column of static oil in the annulus. To treat the rods and the inside of the tubing string, the fluid from the tubing is periodically pumped into the tubing-casing annulus where it displaces the inhibitor slug into and up the tubing. After the slug has been circulated around and back into the annulus, production from the well is turned back into the flow line, leaving the inhibitor slug "parked" in the annulus for future treatments.

With proper operation of this technique, the inhibitor slug can remain effective for several months, depending upon such things as amount of dilution of the slug as well as the magnitude of the corrosion.

## INHIBITOR EVALUATION

Improvements in inhibitor placement techniques have been accompanied by development of more effective inhibitors. However, since all formations and all crudes are different to some degree, it is beneficial to make certain tests in order to evaluate inhibitors for specific problems. Inhibitor A might solve problems in Field A, but be ineffective in Field B.

### Continuous Exposure Test

Probably the oldest method of inhibitor evaluation is the continuous exposure test. A sample of the oil and water from the well to be protected is mixed with a certain amount of inhibitor. A metal specimen is placed in the mixture and is weighed periodically to determine the rate of loss of metal due to corrosion. Comparison with tests of other inhibitors determines the relative effectiveness of the inhibitors.

Fig. 1 represents the results which might be obtained in continuous ex-

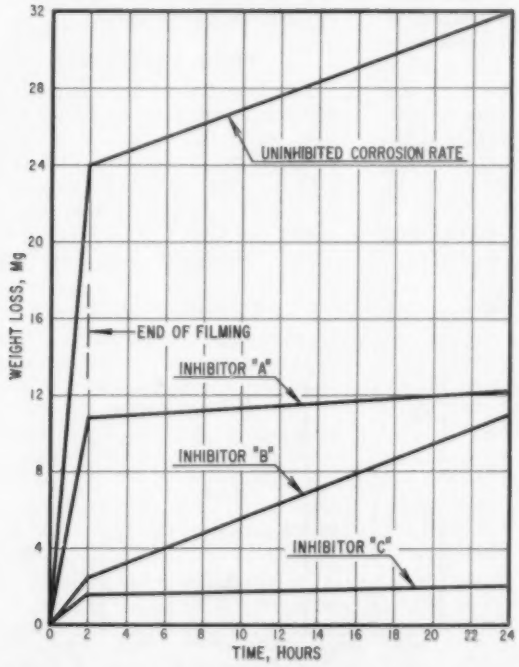



FIG. 3. **Film forming characteristics** of these inhibitors are illustrated in these typical curves. Inhibitor "C" forms a good film in relatively short time and is the most suitable of the three illustrated.

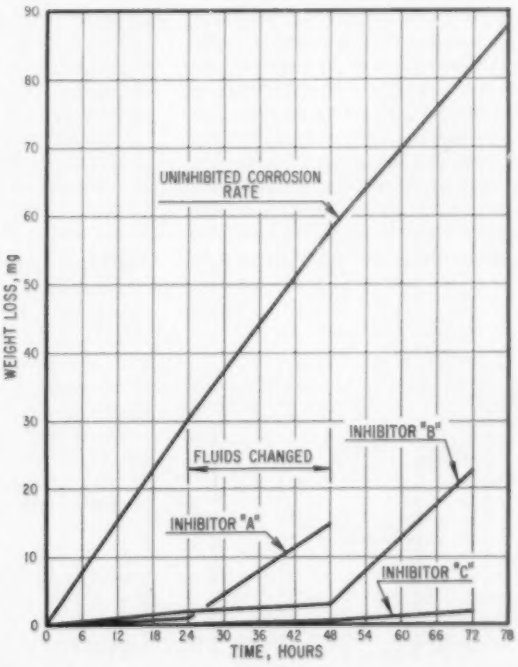



FIG. 4. **Film strength tests**, such as shown in these typical curves, determine the ability of an inhibitor to resist repeated changes of fluid. Inhibitor "C" shows superior characteristics in this test.

posure tests of three inhibitors. In this case, Inhibitor A would be considered satisfactory. The curve for Inhibitor B indicates that it is effective, but overly diluted. Inhibitor C would be unsuitable for fluids in which it was tested but might be satisfactory in some other circumstances.

### Film Persistency Test

The ability of an inhibitor to leave a lasting film on a piece of metal is evaluated in the film persistency test. In this test, metal specimens are immersed in various mixtures of an inhibitor at concentrations from 25,000 to 175,000 ppm. Persistency of this film on the metal specimens is then measured after the specimens are removed from the inhibitor mixtures and placed in other fluids.

Results of such a test are shown in Fig. 2. Inhibitor A shows the ability to form and keep a persistent film. Inhibitor B shows good persistency in lower concentrations but would be avoided if higher concentrations were required for protection. Inhibitor C would appear to be a diluted version of a good inhibitor, while Inhibitor D would be unsatisfactory.

### Film Forming Test

The actual film forming mechanism of an inhibitor can be evaluated by measuring the time required for an inhibitor to lay down a persistent film on a metal specimen.

Fig. 3 represents typical film forming characteristics of three inhibitors. The upper curve shows the corrosion rate of an uninhibited metal sample. Inhibitor A retards the corrosion rate rather slowly for the first two hours at the end of which a fairly persistent film has been formed. Inhibitor B, on the other hand, is a fairly fast film former, but it does not stay when the inhibitor is taken away and new fluids are added. Inhibitor C forms a good film in a relatively short time and is the most suitable.

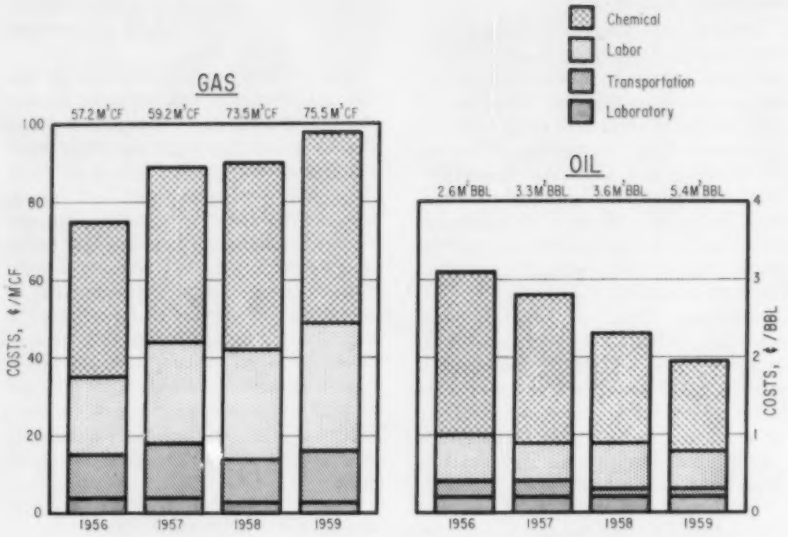



**FIG. 5. Corrosion inhibiting costs** are the final test for any field program. Costs shown above are broken down between gas and oil for Texas Gulf Coast, Louisiana, Mississippi, and East Texas areas.

In some fields, it is very difficult to find an inhibitor which exhibits the characteristics of Inhibitor C. In certain fields of Canada and West Texas results have been no better than exhibited by Inhibitor A.

### Film Strength Test

The ability of an inhibitor to form a film which will resist repeated changes of fluid is determined in the film strength test. In this test, metal specimens are treated with different inhibitor mixtures and are then immersed for a period of time in various different fluids. The point at which the film starts to fail is a measure of its strength.

This test is illustrated in Fig. 4. The standard or uninhibited corrosion rate is represented in the upper curve. Inhibitor A starts to fail after about 24 hours and is the poorest of the three shown here. Inhibitor B loses its strength after about 48 hours, while Inhibitor C continues to be effective for some time.

### Field Correlation

These tests have been very satisfactory in the selection of the appropriate inhibitor for various corrosion problems. They are not absolutely complete, but are better than selecting an inhibitor arbitrarily from the shelf. These laboratory tests were followed up with field applications and very good correlation has been observed.

## FIELD EXPERIENCE

The final test of any equipment or technique, including corrosion inhibition, comes in the field. A good indication of the results of a corrosion inhibition program can be seen in the records of a geographic area which includes the Gulf Coast of Texas, Louisiana, Mississippi and East Texas.

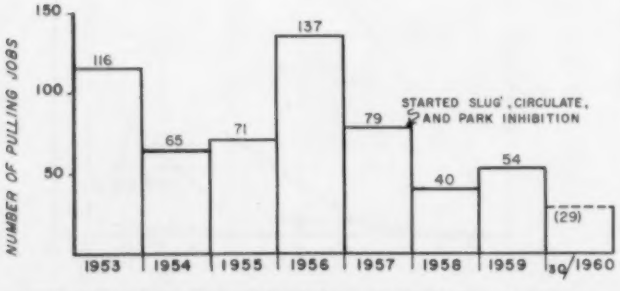



**FIG. 6. Yearly well servicing jobs** on 20 East Texas oil wells. The slug, circulate, and park inhibition method was started on these 20 wells late in 1957. As result, servicing jobs were nearly cut in half the next year.

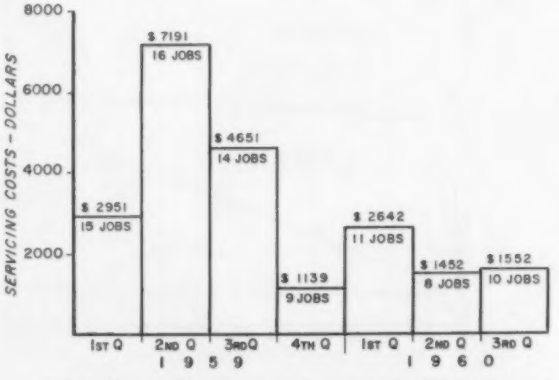



**FIG. 7. Quarterly well servicing costs** for 20 East Texas oil wells show a marked decrease in 1960 over 1959.

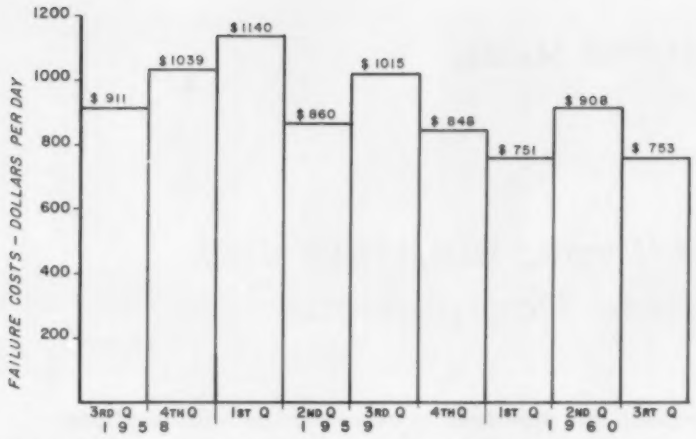



FIG. 8. **Daily failure costs** by quarters for one producing district where records were maintained on about 1000 wells for both surface and subsurface failures.

Average inhibition costs in these areas are shown in Fig. 5.

In 1956, 2.6 million bbl of oil were treated at a cost of about two cents per bbl for all the wells under treatment. In 1959, after improving inhibitor selection and application techniques, 5.4 million bbl of oil were treated at about one cent per bbl. In other words, treatment costs were reduced by 50%, resulting in the spending of the same amount of money to treat twice as much oil.

**Results of gas-well treatment** as shown in Fig. 5 are not as satisfactory. This is due mainly to the fact that several shut-in gas wells were treated by filling the tubing strings with inhibited diesel oil. These wells produce no gas, yet inhibitors are necessary to protect them.

Over these years there was a definite decrease in treatment costs, especially in oil treatment, resulting from closer screening and better application of inhibitors. Labor costs have remained relatively the same and a slight reduction in transportation costs was realized. Laboratory expenses have also remained relatively constant.

### Well Servicing History

Another indication of the effectiveness of the slug, circulate and park inhibition program is shown in the records of some operations in a field of East Texas. Twenty wells in this field were studied. Most of these are marginal and are therefore not restricted by production allowables. The wells are high volume wells producing above 90% water, and total fluid production from them has increased each year.

Fig. 6 is a record of all servicing jobs performed on these 20 wells for any reason, from 1953 through the first three quarters of 1960. Near the end of 1957, the slug, circulate and park inhibition method was started in this field. As a result, well servicing jobs were cut almost in half during the following year. In addition, chemical costs were likewise reduced by 50% in 1958, resulting in twice as much protection at about half the cost. These wells have been inhibited since 1951 and the results obtained from 1953 to 1957 were considered to be satisfactory during that period.

### Well Servicing Costs

In addition to a reduction of well servicing jobs in this field, there has been a corresponding reduction in total servicing costs. This is shown graphically in Fig. 7 which presents pulling costs for 1959 and the first three quarters of 1960 for the 20 wells in the field.

In 1959, 54 pulling jobs were done at a total cost of $15,986. During the first three quarters of 1960, 29 such jobs were done at a cost of $5646. Even if pulling costs in the final quarter of 1960 were another $5000, the saving over 1959 would still be most impressive.

### Failure Costs

Records from one district also show very satisfying results for the corrosion mitigation efforts. About 1000 wells are operated in this district and complete records on their operation have been kept. Fig. 8 represents the costs of all types of failures in this district, both surface and subsurface failures. Cost data are presented as dollars per day for all wells from the middle of 1958 through the first three quarters of 1960.

There have been no drastic changes in the operation of this district, simply a continually closer check on procedures and techniques. Yet, failure costs in 1960 are expected to have been reduced by approximately 20%. It is not unreasonable to expect that these failure costs eventually can be reduced to 25% of the previous expenditure as a result of continued emphasis on the improved engineering techniques concerning corrosion.

## ESSENTIALS OF SUCCESSFUL PROGRAM

Although there are many things which are essential to the success of a corrosion control program, there are three things without which no program can be effective.

### Adequate Mechanical Design

The proper design and operation of equipment is most important to corrosion control. Improper design of tubing strings, or rod strings, or other components leads to rapid corrosion-mechanical failure. Bad field practices, such as use of hammers and improper joint makeup, must be eliminated.

### Attitude of Personnel

An effective corrosion control program must be backed by the proper attitude of personnel at all levels. This should be a minor problem if the program is well designed around sound engineering practices leading to reduced costs.

Many people have lived with corrosion problems for years and have come to expect failures as surely as they expect to pay taxes. But this attitude must give way to a sincere desire on the part of supervisors to control these problems.

### Proper Records

Evaluation of the effectiveness of any program can be made only with complete records. Chemical costs, labor costs, transportation costs, types and frequency of failures, well servicing costs . . . these are only a few of the items which must be properly recorded for thorough evaluation of the corrosion control program.

These three essentials, plus a good inhibitor program to begin with and a systematic follow-up of the work, have resulted in a lowering of operating costs. * * *


#### ABOUT THE AUTHOR

**D. R. Fincher** is a research chemical engineer in the Exploration and Production Research Department of Tidewater Oil Company at Houston, Texas. A graduate of Texas A & M College in 1948 with a BS degree in Chemical Engineering, he has worked for Tidewater since graduation. He has held various engineering posts in the Production and Gas Utilization Departments until July 1959 when he was assigned his present position. Fincher has been active in corrosion work with NACE and NGAA. He served as chairman of the NACE Committee on *Condensate Well Corrosion* and of the NGAA *Gasoline Plant Corrosion* Committee. He is currently chairman of the NACE Committee T-1G, *Protective Coatings and Non-Metallic Goods for Oil Field Use*. He is also a member of AIME.

MODERN WELL COMPLETION SERIES

PART 10A

# Permanent-Type, Multiple and Tubingless Completions

**First of a 2-part report on the development and application of permanent-type well completions**

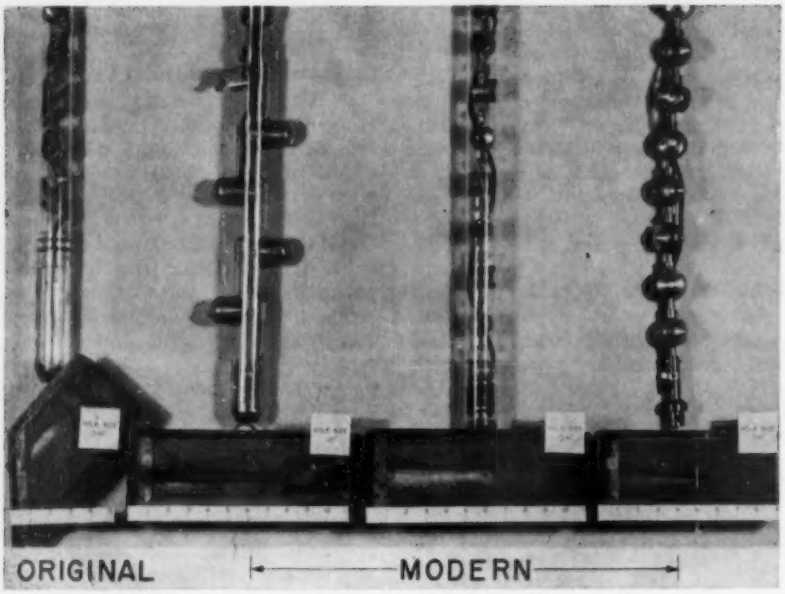



FIG. 1. **Tubing type perforators,** now available to run through 1½-in. or larger tubing, were first used in the field in late 1950.

T. A. HUBER • C. B. CORLEY, JR.
*Humble Oil and Refining Compny, Houston, Texas*

THE UPWARD TREND in finding, developing, and producing costs poses a real challenge to the domestic petroleum industry. During the past 10 years, two of the most important tools for cost reduction have been: (1) the development and application of permanent-type well completion methods and associated procedures; and (2) the improvement in equipment and techniques for multiple completions.

Successful experience with these two well completion methods and development associated with working through well tubing have resulted more recently in the use of conventionally sized tubing as casing, including completion of multiple wells by cementing two or more strings of small-diameter pipe in the same drilled hole for production from multiple reservoirs.[1]

## PERMANENT-TYPE COMPLETIONS

A permanent-type completion involves placing the lower end of the well tubing above one or more potential producing intervals and subsequently performing all completion and recompletion work with small tools that pass through the tubing. After the well casing has been set and cemented, this type completion can be used with any common size casing and tubing provided the well is properly equipped.

The concept of permanent-type completions was first introduced to the Industry at the 30th Annual API Meeting in Los Angeles, California, in November 1950, and was described as the engineer's approach toward improving completions for maximum recovery at lower cost.[2] A complete workover was first performed on a well without the use of a rig in the spring of 1952.[3] Since that time, many workovers on single and dual completions have been performed by utilizing small tools run on a wireline through the well tubing. In addition, a large number of workovers have been performed using phases of the permanent completion method without actually employing wireline equipment. Cost reductions of the regular permanent completion operation compared with conventional workover methods have been 30% on land locations, 53% on inland water locations, and 85% offshore.[4]

The basic tool of the through-tubing completions and workover methods is the new familiar through-the-tubing perforator which was first used in the field in late 1950 (Fig. 1). These perforators, now available to run through 1½-in. or larger tubing, continue to keep pace with the larger casing guns and generally provide superior perforating performance because they can be used in the presence of a non-plugging well fluid with safety even if a surface well pressure exists.[5]

### Wireline Operations

The ideal time to equip a well for permanent completion work is during the initial well completion. For existing wells which have not been completed for wireline through-tubing operations, it is generally necessary to pull the tubing to make the installation of requisite equipment. Many existing completions have been economically equipped for

This article is one of a series of Modern Well Completions based on lectures given by industry authorities before a Petroleum Engineering Seminar course, PE 270, at The University of Texas, Austin.

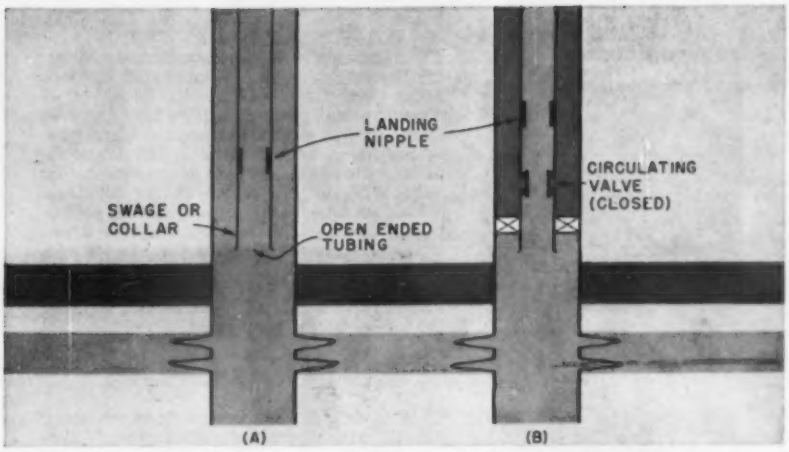



**FIG. 2. Permanent-type well completions** for single zones can be with open-ended tubing (2A) or with a packer and circulating valve (2B).

permanent well completion during routine well servicing or recompletion operations. With the proper equipment in the tubing string, wireline workover of wells can be accomplished without disturbing the tubing and wellhead installation.

The following basic requirements must be observed in order to rework any type well with wireline tools.[6]

1. Tubing string must be open-ended and essentially full-open.

2. Bottom of tubing should be positioned above all desired completion intervals. For convenience, wells are normally completed such that 1000 ft or less of tubing extension is required on a wireline workover.

3. A circulating means between the tubing and casing annulus must be provided. In wells equipped with a tubing packer, a wireline-operated circulating valve must be installed between the landing nipple and the packer to permit circulation between the tubing and casing annulus during workover.

4. Tubing string and wellhead must be pressure-tight.

## Well Installations, Single Completions

Equipment requirements for permanent-type well completion are based on well producing characteristics and the type completion desired. To aid in fulfilling installation requirements, the basic types of installations are described below with specific comments on wireline equipment and procedures employed.

**Wells without packers.** In a single completion without a packer, the only requirement for a wireline workover is a landing nipple which provides a recess for locking and a polished surface for sealing the tubing extension pipe hanger (Fig. 2A). The landing nipple should be installed near the bottom of the tubing string in order to minimize the length of tubing extension pipe needed for recompletion.

**Wells with packers.** For wireline permanent completion operations in a single completion containing a packer, a wireline-operated circulating valve must be installed between the landing nipple and the packer in order to obtain communication between the tubing and casing annulus during the workover operation (Fig. 2B). The valve is closed during normal production. It is essential that the circulating valve and packer be full-open. In addition, the packer should be set with as little weight as possible to avoid distorting the tubing, as it should hold substantial pressure differential from either direction.

**Gas-lift wells.** Both the offset and concentric-type gas lift mandrels which accommodate wireline retrievable valves can be used for permanently completed wells. Gas lift mandrels are often run on initial completion when it is anticipated that gas lifting will be required in the future, but it is sometimes economically desirable to defer the installation of the lift equipment until it is determined that the well will not flow.

A gas lift well is equipped for wireline permanent completion work in the same manner as a flowing well. During workover the gas lift valves are retrieved, and tubing is made pressure-tight by installing dummy valves in offset mandrels or by shifting sliding sleeves to the closed position where concentric-type gas lift mandrels are employed.

**Pumping wells.** In rod-pumped wells, a landing nipple can be installed which will serve the dual role of receiving either the tubing extension pipe hanger or the rod pump holddown. This interference-type landing nipple can be used with a cup-type pump holddown, but only one such nipple may be run per tubing string. If the rod pump is to be set high in the well, two or more selective-type landing nipples can be employed with the lower nipple installed for permanent completion work. A special pump holddown with selective keys may be used with the selective nipple.

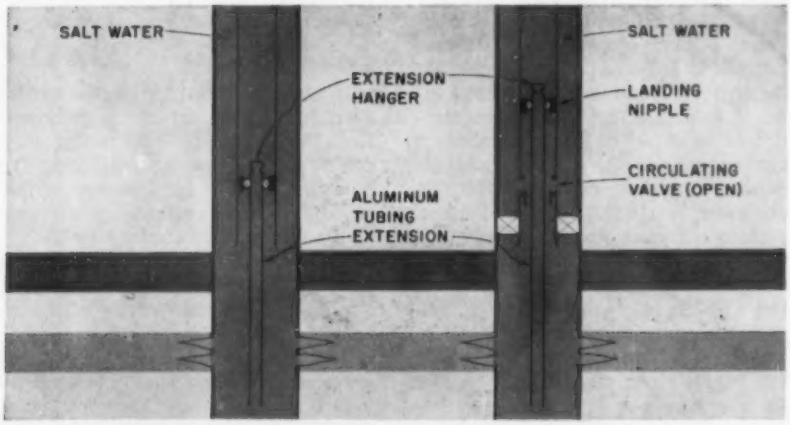



**FIG. 3. Retrievable tubing extension** of 1-in. aluminum pipe extends the effective length of the tubing down to or through the perforated interval in both types of single completions.

## Retrievable Tubing Extension

For wireline workover operations, a tubing extension consisting of 1-in. aluminum pipe is installed to extend the effective length of the tubing down to or through the perforated interval (Fig. 3). An extension hanger is used to seal and lock the tubing extension in the landing nipple and to suspend the extension pipe. The tubing extension assembly is lowered through the tubing on a small wireline until the extension hanger is seated in the landing nipple.

When the extension hanger is locked in the nipple, the wireline running tool is retrieved, and circulation can then be obtained to the bottom of the tubing extension pipe. Following the desired workover operations, a wireline pulling tool is used to retrieve the tubing extension.

### Low-Pressure Squeeze-Cementing

A special cement mixture called modified cement is used on permanent completion squeeze-cementing operations. Squeeze pressures are lower than usually required for conventional high-pressure squeeze-cementing; hence, the technique is termed "low-pressure squeeze-cementing."[7] In the low-pressure squeeze-cementing method it is undesirable to fracture or break down the formation prior to the cementing operation, and surface squeeze pressure of 1000 to 2000 psi are used. Small quantities of cement, usually 8 bbl of slurry, are normally employed in the cementing operation. The need for removing the well tubing to install a squeeze packer and for subsequently drilling out the packer and cement is eliminated when the low-pressure squeeze-cement technique is employed in conjunction with permanent completion operations.

Modified cements had been previously developed for primary casing cement. The addition of bentonite and a retarder to common portland cement to obtain a modified cement permits accurately controlling the pumpability time of the slurry; and it significantly reduces the filtration rate or water loss. Neat cement cannot be used for low-pressure squeeze-cementing because its high filtration rate results in rapid slurry dehydration, even into the well casing itself, preventing removal of excess cement slurry by reverse circulation.

Low-pressure squeeze-cementing operations are divided into plugback jobs and set-through cementing jobs. Plugback jobs leave cement slurry in the casing opposite the perforations and are used when a zone is permanently abandoned and the well is to be completed in a higher zone. Set-through squeeze-cementing leaves the well bore open through the previously perforated interval and permits reperforating all or a portion of the old interval or completing in a lower zone. The same basic method of squeeze-cementing is used with both plugback and set-through jobs.

When it is impossible to squeeze salt water or other workover fluids into a formation without fracturing the formation, a plug cutter and reverse check are used with the tubing extension as a means of spotting a displacement-type cement plug across a producing interval (Fig. 4). The reverse check is placed on the bottom of the tubing extension, and the plug cutter is placed in the extension at the point at which it is desirable to leave the top of the cement plug. If it is possible to squeeze workover fluids into the formation at low pressure, the lower end of the tubing extension is positioned at the point in the casing to which the well must be left free of cement.

For plugback jobs, modified cement containing 12% by weight of bentonite is generally selected because its faster strength development permits less waiting-on-cement time. Modified cement containing 25% bentonite is generally selected for set-through jobs where all excess cement is removed by reverse circulation to leave the well bore open through the previously perforated interval (Fig. 5). The higher concentration of bentonite in the 25% modified cement reduces the size of the node buildup inside the casing and permits easily running small tools, such as a perforator, through the squeezed interval. The quantity of retarder used with either 12 or 25% modified cement varies with the reservoir temperature and with the pumpability time required.

After the cementing slurry is mixed, it is pumped into position by displacing the cement down the tubing and following the slurry with the correct volume of workover fluid. The cement is displaced around the extension and up the well bore until it extends above the perforations, or the cement plug cutter, before a surface squeeze pressure is applied. After a sustained surface squeeze pressure is obtained, the excess cement is removed from the well by reverse circulation.

Experience has shown that it is not necessary to test a plugback job if the cement plug is found above the squeeze perforations. When testing a set-through cement job, it is preferable to test by creating a pressure differential into the well bore by swabbing or by placing a light fluid, such as oil, in the well. Following a satisfactory test of the squeeze-cementing operation, the desired interval may be perforated and production initiated.

### Sand Removal

In a well equipped for wireline workover, formation sand can be removed from the casing below the tubing with a telescoping tubing extension (Fig. 6). After the distance from the top of the sand to the tubing extension landing nipple has been determined by use of a wireline locator tool, the extension is seated in the landing nipple by wireline. Over-all length of the extension is measured with the telescoping joints in the collapsed position. With the lower end of the tubing extension resting on the sand, the telescoping joints will extend in length as sand is reverse-circulated from the well, permitting the lower end of the extension to re-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C. B. Corley, Jr. is in charge of coordinating subsurface engineering development and practices other than drilling and corrosion for the Humble Division of Humble Oil and Refining Company. He was graduated from Duke University with a BS degree in electrical engineering in 1949 and then joined Humble as a roustabout and rotary helper. After field work, he worked on production and drilling operations and then in equipment and reservoir engineer. In 1956, he was transferred to the Houston office to work on development of well completion equipment and practices.

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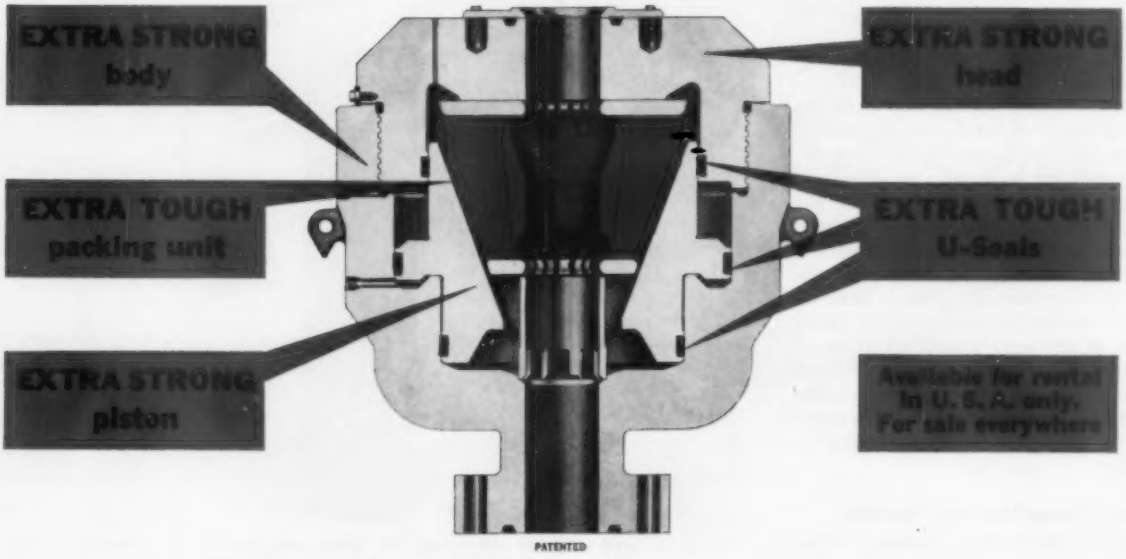
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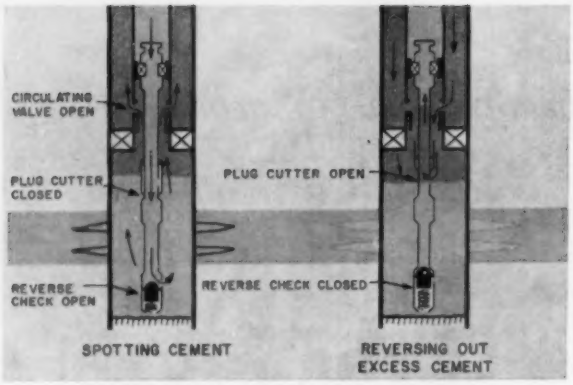



FIG. 4. **Aluminum tubing extension with plug cutter** for spotting and reversing out excess cement in a plugback operation.

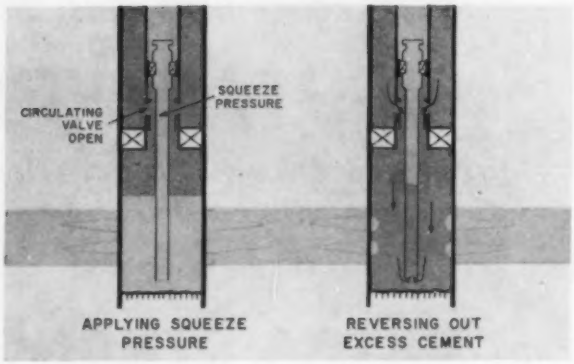



FIG. 5. **Set-through squeeze cementing** with extension pipe where it is desired to run small tools, such as a perforator, through the squeezed interval.

main in constant contact with the top of the sand.

Sand can also be removed from the well tubing if the well contains a multiplicity of circulating valves. Telescoping joints are used with an extension hanger which seals and locks at a tubing-collar recess. As sand is removed and a lower circulating valve is uncovered, the telescoping tubing extension can be successively lowered until all sand is washed from the tubing. Many wells in the sand producing areas of the Gulf Coast are equipped with landing nipples and circulating valves placed at approximately 1500 ft intervals to facilitate washing sand from the tubing.

### Sand-Consolidating Plastics

Sand-consolidating plastics, which control production of sand by bonding formation sand grains in place, were developed approximately 15 years ago, but early field trials resulted in poor success[8] because of completion techniques which were prevalent at that time. All wells were initially perforated in drilling mud, and some mud-plugged perforations were probably always present to prevent the entry of plastic into all of the formation sand. Pressure differentials in the well bore during production of the consolidated wells dislodged the mud plugs, again permitting sand production.

In early 1957, field trials of consolidating plastic for sand control were revived with the thought that improved completion procedures brought about by evolution of the permanent-completion technique would permit adequate treatment of all formation sand open for production and provide increased success. Permanent completion procedures permit perforating and subsequent operations to be performed with clean, nonplugging fluid in the well such that all perforations remain open for injection of the plastic. The use of a tubing extension to place the plastic material opposite the entire perforated interval prior to squeezing enhances the possibility of injecting at least some plastic into each perforation hole (Fig. 7).

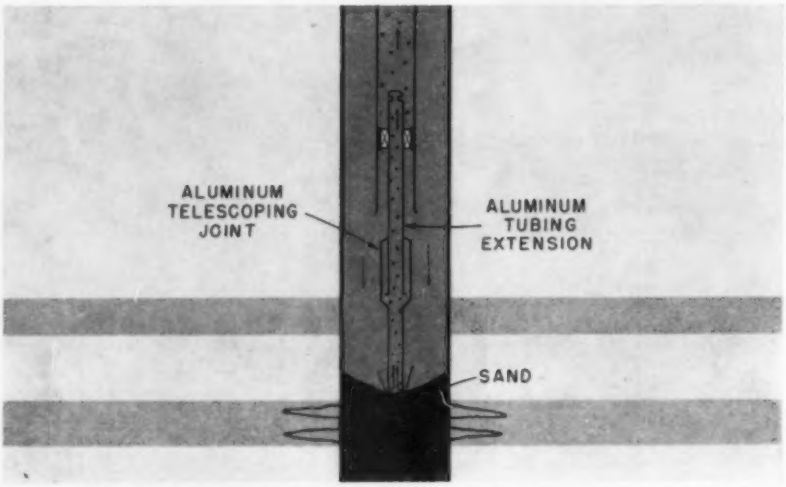



FIG. 6. **Sand removal** with telescoping tubing extension where the sand is located below the lower end of the tubing in a permanent-type well completion.

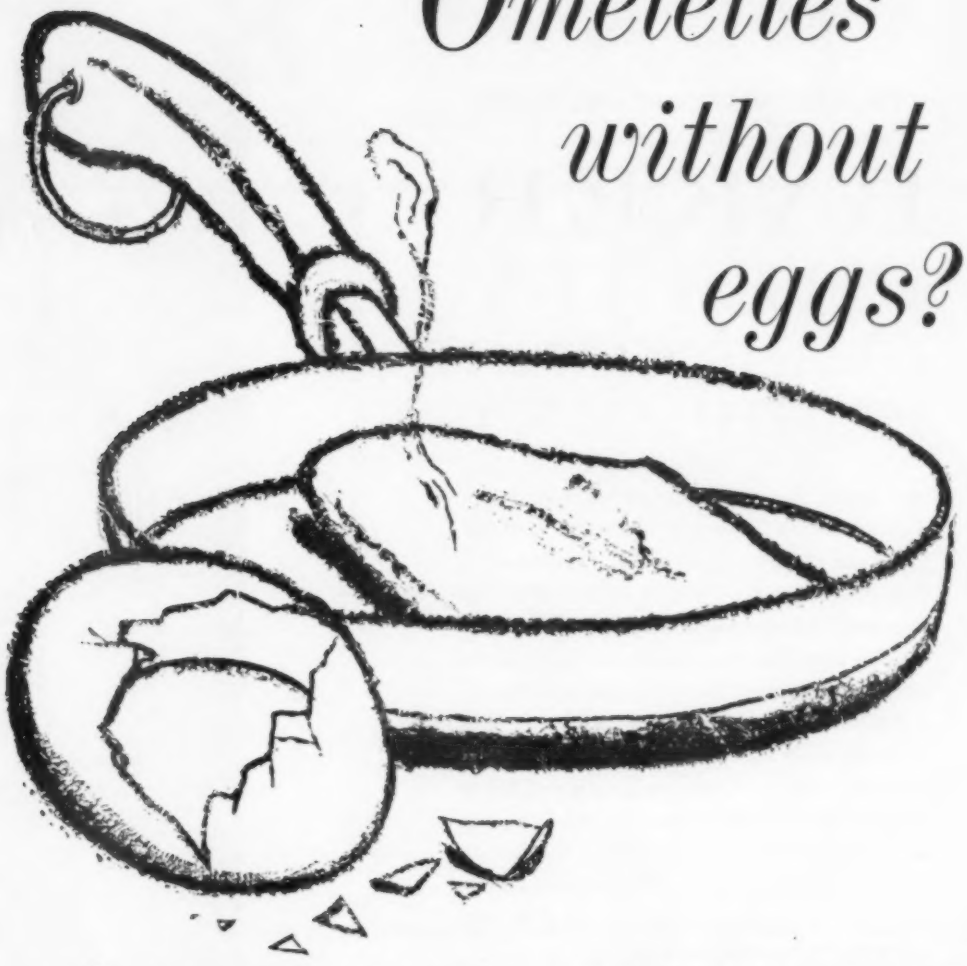
Success of consolidating plastic as a sand control measure has been gratifying since adopting permanent completion methods for plastic placement. Closely associated with higher job success are improvements which have been made during recent years in the plastic technique itself. The plastic method of sand control is considered very important because it eliminates the need for screens inside the casing and, therefore, permits placement by permanent completion methods and subsequent use of through-tubing techniques during workover operations. Consolidating plastics are particularly attractive for use in the upper intervals of multiple completions and for tubingless completions.

## PULLING UNITS OPERATIONS

If a well is not equipped for wireline permanent completion work or when the well tubing or sucker rods and pump must be pulled, a small rig or pulling unit can often be used economically for the workover by utilizing the low-pressure squeeze-cementing technique and the through-the-tubing perforator. No special equipment except a stripper-type blowout preventer is required for workover of a well in this manner, but the tubing must be full-open and open-ended to permit use of the through-the-tubing perforator.

After the rods and pump are pulled, well tubing can be pressure-tested and additional joints of tubing added until the lower end of the tubing string is at proper depth, usually in the vicinity of the perforations. A pump-down test tool, dropped into the tubing and circulated into the pump-seating nipple to effect a seal, is used for pressure-testing. The tool may be retrieved by reverse circulation or by wireline. A low-

# *Omelettes without eggs?*



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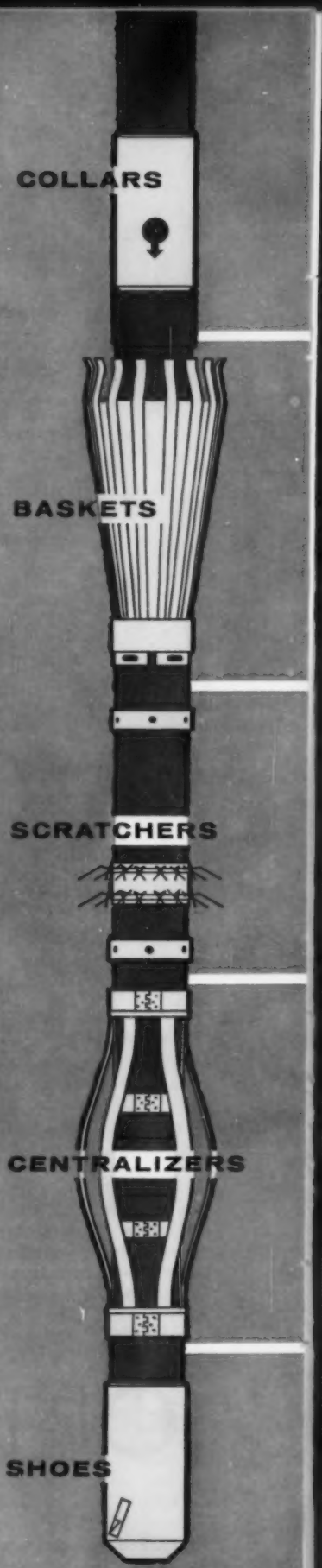


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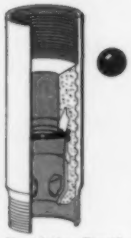

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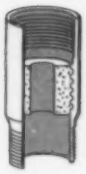


Cement Baffle Collar,
with Hole
Product No. 104 M&F

Cement Baffle Collar,
Solid
Product No. 105 M&F

Triplex
Flapper Valve
Float Collar,
Product No. 134 M&F

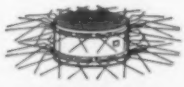
Metal Petal Basket,
with Stop Rings
Product No. 343

Plain Hook-Up Nipple
with Metal
Petal Basket
Product No. 330

Avoid welding . . .
lock casing shoes
and collars with
BAKERLOK
Thread-Locking
Compound
Product 050

Hinge-Lok Wall
Scratcher, with
4½" long wires
Product No. 900-C

Hinge-Lok Wall
Scratcher, with
2½" long wires
Product No. 900-C



Solid-Ring Wall
Scratcher, with
4½" long wires
Product No. 901-C

Solid-Ring Wall
Scratcher, with
2½" long wires
Product No. 901-C

Hammer-Lok
Stop Rings
Product Nos.
940-B (Solid)
and 945-B (Hinged)

Rotating
Wall Scratcher
Product No. 903

"G-12" Slim Hole
Casing Centralizer
Product No. 910-G

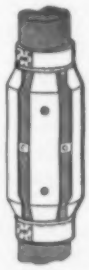
"HN-15" Solid-Ring
Casing Centralizer
Product No. 908-HN

"HN-20" Solid-Ring
Casing Centralizer
Product No. 908-HN

"H-15" Hinge-Lok
Casing Centralizer
Product No. 9115

"H-20" Hinge-Lok
Casing Centralizer
Product No. 9112

"H-25" Hinge-Lok
Casing Centralizer
Product No. 9113



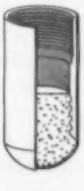
Hinge-Lok Rigid
Casing Centralizer
Product No. 9133

Differential
Fill-Up Shoe
Product No. 1081

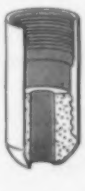
Flexiflow
Fill-Up Shoe
Product No. 160

Cement
Float Shoe
Product No. 100

Cement Wash-Down
Whirler Float Shoe
Product No. 120



Cement
Bull Plug Shoe
Product No. 103



Cement Guide Shoe
Product No. 102

Triplex Cementing Shoe Product No. 1363

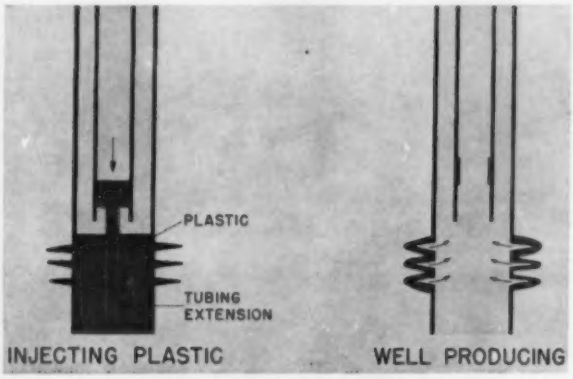



FIG. 7. **Wire line method** of placing sand consolidating plastics. The tubing extension makes it possible to spot the plastic material opposite the perforations prior to squeezing.

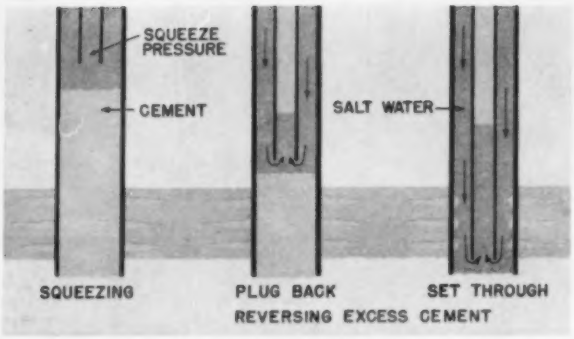



FIG. 8. **Low-pressure squeeze cementing** with the well tubing by displacing modified cement across the perforations, raising the tubing above the cement, applying a squeeze pressure, and then lowering the tubing while reverse-circulating the excess cement until the desired depth is reached.

pressure squeeze-cementing operation can then be performed by displacing modified cement across the perforations, raising the lower end of the tubing above the cement slurry, applying a squeeze pressure, and then lowering the tubing while reverse-circulating the excess cement until the desired depth is reached (Fig. 8).

For low-pressure squeeze-cementing operations with a pulling unit, 12% modified cement is generally selected for both plugback and set-through cementing jobs because any excessive node buildup inside the casing will be removed when the tubing is lowered for reverse circulation of excess slurry.

## CONCENTRIC TUBING WORKOVERS

Small macaroni tubing such as ¾-in. or 1-in. upset tubing, run from the surface inside the well tubing, has been used successfully to wash sand from the well bore, to treat with consolidating plastics, and to conduct low-pressure squeeze-cementing operations.[9] The concentric tubing workover method utilizing a small low-cost pulling unit is especially attractive in wells containing packers with gelled mud in the casing annulus, in wells where packers were installed to isolate casing leaks, and in wells which were not originally equipped for wireline workover. If the well tubing is essentially full-open except for a bull plug on bottom, equipment is available to cut the tubing below the packer which allows the bull plug to drop to bottom.

The concentric workover method has been used on wells to depths of 12,000 ft with costs competitive with wireline operations. Circulating pressure in deep wells may reach 2000 psi with a circulating rate of less than ½ bbl per min. It is not necessary that the circulating rate be high because the fluid velocity in the small macaroni tubing and in the annulus between the well tubing and the small tubing is sufficient at low rates to wash and to squeeze-cement.

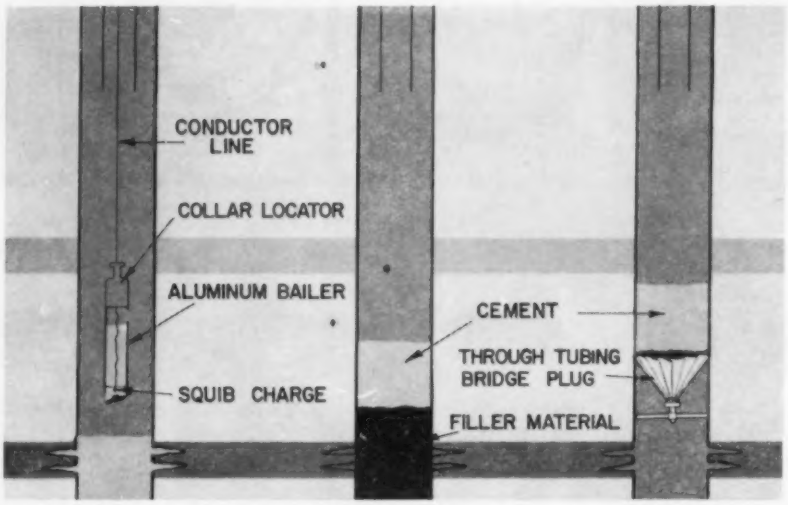



FIG. 9. **Through tubing dump bailer and bridge plug** used to perform cement plugbacks in the Gulf coastal areas of Texas and Louisiana.

## DUMP BAILER PLUGBACK METHODS

During the past 3 years, use of through-tubing dump bailers to perform cement plugbacks has become popular in the Gulf coastal areas of Texas and Louisiana. Dump bailers are utilized to place cement across a perforated interval or on top of (1) filler material, such as marbles or gravel, or (2) a through-tubing bridge plug (Fig. 9). Because the majority of available through-tubing bailers and all of the through-tubing bridge plugs are designed for running on a perforator conductor line and perforating can be performed on the same well setup, this type workover operation has proved very attractive.

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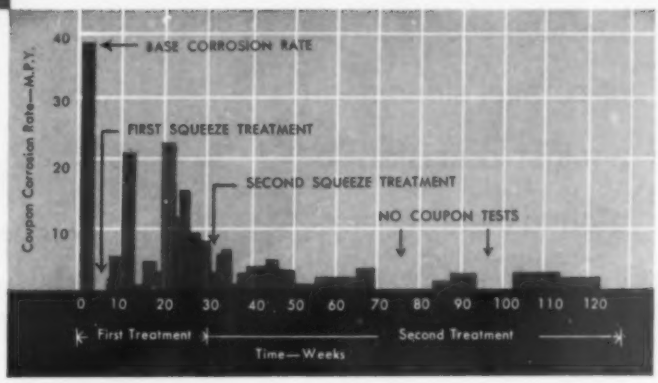
4. Tausch, G. H., and McDonald, Price: "Permanent-Type Completions and Wireline Workovers," *The Petroleum Engineer*, (Sept. 1956) Vol. 28, No. 10, p. B-39.
5. Bell, W. T., and Lebourge, M. P.: "Perforating Today — A Science," API Southwestern District Spring Meeting, Midland, Texas, Mar. 4 - 6, 1959.
6. Tausch and McDonald, *op. cit.*
7. Tausch, G. H.: "Squeeze Cementing with Permanent-Type Completions," *Oil Well Cementing Practices in the United States*, API, New York, N.Y., 1959, p. 161.
8. Edwards, J. H., Williams, R. E., and Prokop, C. L.: "An Improved Technique for Consolidating Sand in Oil and Gas Wells," API Southern District Spring Meeting, New Orleans, Louisiana, March 25 - 27, 1959.
9. Goeken, R. J.: "Report of the Methods and Results of Concentric-Tubing Workovers," API Southern District Spring Meeting, Houston, Texas, February 26 - 28, 1958.

**TO BE CONTINUED**

**The second and final part of this report which will discuss multiple and tubingless completions will be published next month.**

another
# TRETOLITE SERVICE
report




*Corrosion history of a West Texas well, showing coupon corrosion rate with time*

## KONTOL *puts the squeeze on corrosion*

Results at a West Texas well show why the KONTOL* Corrosion Inhibitor squeeze technique is rapidly gaining favor with producers everywhere. Located in Crane County, this well is completed in San Andres pay at 3,500 feet. Production rate is 70 bbl. per day, with just a trace of water. It was decided to try KONTOL inhibitor squeeze after coupon testing showed a corrosion rate of approximately 39 m.p.y., and rods were beginning to pit.

### KONTOL *treating is simple*

Inhibitor squeeze treating began by pumping a mixture of 30 gallons of KONTOL dispersed in 100 bbl. of crude oil into the formation through the casing-tubing annulus. This was followed by a 100 bbl. crude oil overflush. Surface pressure was approximately 1,000 psi during the squeeze. Following this treatment, the well was closed for 20 hours.

### KONTOL *results are positive*

During the first five months following treatment, the corrosion rate varied from a high of 21 m.p.y. to a low of 0.5 m.p.y. For 11 weeks of this period the rate was below 5.0 m.p.y. No equipment failures due to corrosion were reported during the five-month period.

### KONTOL *protection is long-lasting*

Six months after original squeeze treatment the corrosion rate was still satisfactory, but it was decided to resqueeze the well to make certain of uninterrupted protection. During the following 90 weeks, coupon tests showed a corrosion rate that averaged 2.0–3.0 m.p.y.—proof of KONTOL's enduring effectiveness.

*Ask the Man in the Red Car to explain how* KONTOL *Corrosion Inhibitor squeeze treating offers advantages over conventional batchtreating methods. Let him prove why* KONTOL *can be applied more easily and economically, with lasting results.*

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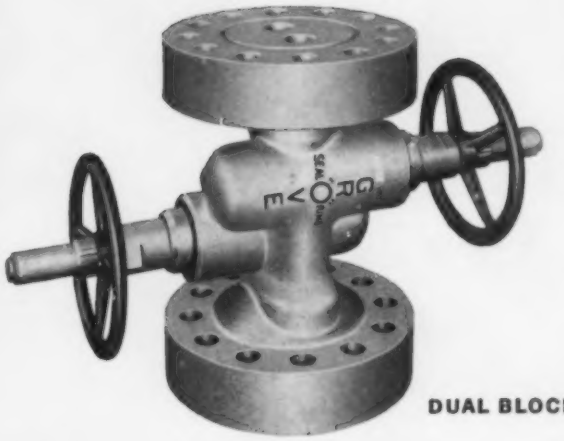
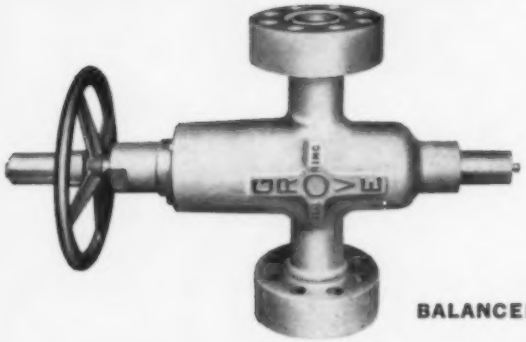


DUAL BLOCK



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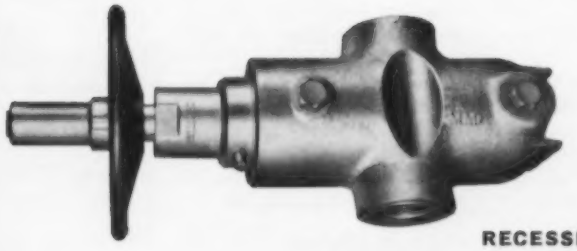

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# ESTIMATING OIL RESERVES FROM PRODUCTION DATA

W. F. STEVENS AND GEORGE THODOS
*The Technological Institute, Northwestern University*

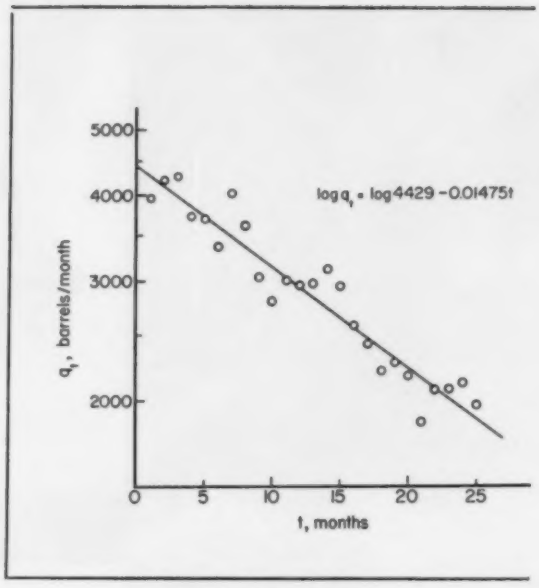


FIG. 1. **Field data** fitted to a constant percentage decline curve.

**Three common production decline curves can be used to estimate total oil reserves and total production at abandonment. Selection of the proper curve and evaluation of results are discussed.**

PRELIMINARY ESTIMATES of oil reserves often may be obtained from geologic data, but no information is readily available concerning the extent of primary oil recovery to be anticipated. Calculation procedures can be developed to give this information for the idealized cases of gas-cap drive, internal-gas drive and water encroachment. Although the results of such calculations are valuable, more reliable and easily obtainable estimates of future recovery can be made from actual production data. The longer a field has been on production, the more dependable are these predictions.

Production data may best be used for estimating oil reserves through the extrapolation of production decline curves. Such curves relate the instantaneous production rate to time or to cumulative production. Arps† has summarized the different types of production decline curves along with the mathematical bases underlying their use.

## PRODUCTION DECLINE CURVES

Three types of decline curves are commonly recognized: constant percentage decline, hyperbolic decline, and harmonic decline. When production is not restricted, the rate decreases continuously with time until it reaches an uneconomical level. The instantaneous decline rate, D, is used to differentiate between the three types of decline curves. By definition,

$$D = -\frac{dq_t/dt}{q_t} = -\frac{d\ln q_t}{dt} \quad . \quad . \quad . \quad . \quad (1)$$

For constant percentage decline, D is independent of production rate, while for harmonic decline, D is directly proportional to production rate. Hyperbolic decline is an intermediate case in which D is proportional to a fractional power, s, of the production rate ($0 < s < 1$).

### Constant Percentage Decline

For this case, $D = \alpha q^0$; therefore $\alpha = D$. Rearranging and integrating Equation 1, it follows that

$$q_t = q_o e^{-Dt} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Equation 2 can be simplified by recognizing that

$$e^{-D} = 1 - D + \frac{D^2}{2!} - \frac{D^3}{3!} + \ldots\ldots$$

Since $D << 1$, a good approximation results from the truncated series:

$$e^{-D} \approx 1 - D$$

When this substitution is made in Equation 2, the following commonly encountered expression is obtained:

$$q_t = q_o(1 - D)^t \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Using Equation 3, the cumulative production, $Q_t$, up to time t becomes

$$Q_t = \frac{q_t - q_o}{\ln(1 - D)} \quad . \quad . \quad . \quad . \quad . \quad (4)$$

The rate-time relationship of Equation 3 indicates that a plot of log $q_t$ versus t gives a straight line of slope equal to log $(1 - D)$. Similarly, the rate-cumulative relationship of Equation 4 indicates that a plot of $q_t$ vs $Q_t$ is also linear and of slope $2.303\log(1 - D)$.

Production is ordinarily continued until an economic limit rate is reached below which the direct operating expense exceeds the return from the oil produced. When production from a well reaches this limiting value, the well is usually abandoned. The time of abandonment, $t_a$, is the time at which the economic limit rate, $q_a$, is reached. At this time, the total cumulative production is $Q_a$.

†Arps, J. J., "Estimation of Primary Oil Reserves" *AIME Trans. 207*, 182 (1956).

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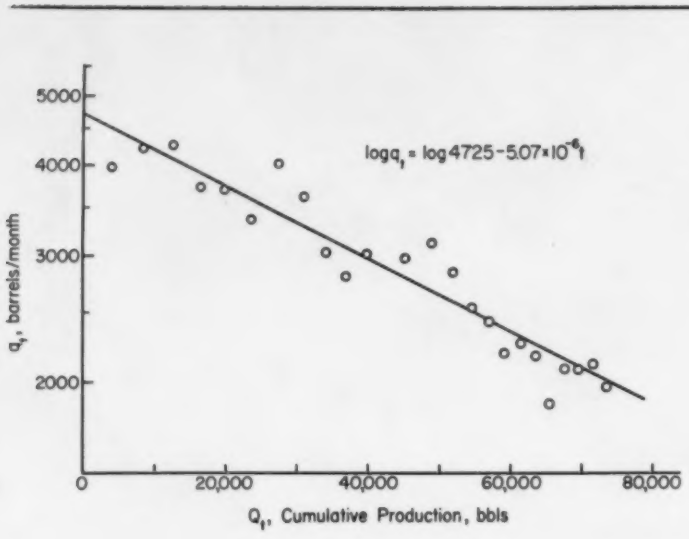


FIG. 2. **Cumulative production** data fitted to a harmonic decline curve.

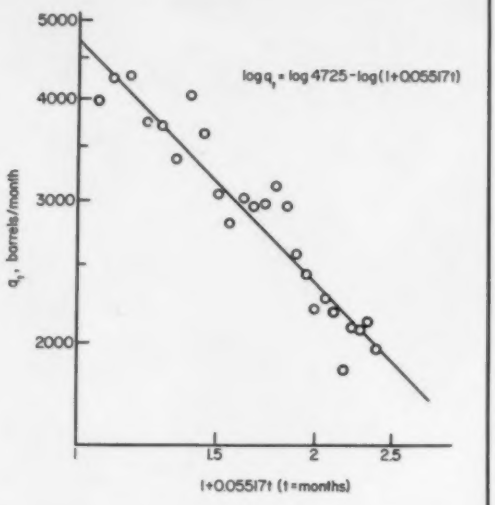


FIG. 3. **Production rate data** fitted to a harmonic decline curve.

When Equation 3 is applied to this limiting condition, the following expression for $t_a$ results:

$$t_a = -\frac{\ln r}{\ln (1-D)}, \text{ where } r = \frac{q_o}{q_a} \quad . \quad . \quad . \quad (5)$$

Combining Equation 5 with Equation 4, for abandonment conditions, gives the following expression:

$$Q_a = q_o t_a \frac{r-1}{r \ln r} \quad . \quad . \quad . \quad . \quad . \quad (6)$$

### Harmonic Decline

For this case, $D = \alpha q$. If $D_o$ is the initial decline associated with the initial production rate, $q_o$, then $\alpha = D_o/q_o$. Therefore $D = (D_o/q_o)q$. Under these conditions, Equation 1 can be integrated and rearranged to give

$$q_t = \frac{q_o}{1 + D_o t} \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

With Equation 7, the cumulative production, $Q_t$, becomes

$$Q_t = \frac{q_o}{D_o} \ln \frac{q_o}{q_t} \quad . \quad . \quad . \quad . \quad . \quad (8)$$

Therefore, a plot of log $q_t$ vs $\log(1 + D_o t)$ gives a straight line of slope $-1$, and a plot of log $q_t$ vs $Q_t$ gives a straight line of slope $-D_o/2.303q_o$.

When Equation 7 is applied to the time when the economic limit rate is reached, the following expression for $t_a$ results:

$$t_a = \frac{r-1}{D_o} \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

Combining Equation 9 with Equation 8, for abandonment conditions, results in the following expression:

$$Q_a = q_o t_a \frac{\ln r}{r-1} \quad . \quad . \quad . \quad . \quad . \quad (10)$$

### Hyperbolic Decline

For this case, $D = \alpha q^s$, where $0 < s < 1$. If $D_o$ is the initial decline associated with the initial production rate, $q_o$, then $\alpha = D_o/q_o^s$. Therefore, $D = (D_o/q_o^s)q^s$. As before, Equation 1 can be integrated and rearranged to give

$$q_t = \frac{q_o}{(1 + sD_o t)^{1/s}} \quad . \quad . \quad . \quad . \quad . \quad (11)$$

Using Equation 11, the cumulative production, $Q_t$, up to time t, becomes

$$Q_t = \frac{q_o^s}{(1-s)D_o} \left[\frac{1}{q_o^{s-1}} - \frac{1}{q_t^{s-1}}\right] \quad . \quad . \quad (12)$$

It can be seen that a plot of log $q_t$ vs log $(1 + sD_o t)$ produces a straight line of slope $-1/s$, for the proper selection of s, and a plot of log $q_t$ vs log $[q_o - (1-s)\ D_o Q_t]/q_o^s$ gives a straight line of slope $1/(1-s)$.

When Equation 11 is written for the time of abandonment, the following expression for $t_a$ results:

$$t_a = \frac{r^s - 1}{sD_o} \quad . \quad . \quad . \quad . \quad . \quad (13)$$

Combining Equation 13 with Equation 12, for abandonment conditions, gives the following expression:

$$Q_a = q_o t_a \left(\frac{s}{1-s}\right) \frac{1 - r^{s-1}}{r^s - 1} \quad . \quad . \quad . \quad (14)$$

### Application of Equations

In order to predict the probable reserves of a reservoir, it is necessary to determine which type of decline curve best represents the production performance actually encountered. To this end, attempts are usually made to fit the available production data to one of these commonly recognized types of decline curves. Since production data ordinarily exhibit sufficient scatter to make visual selection of

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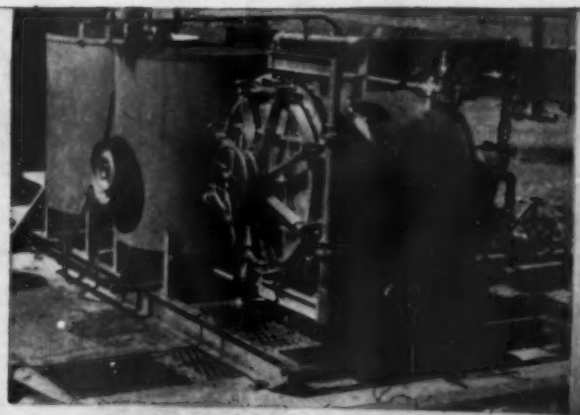

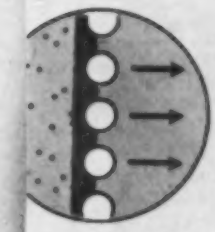

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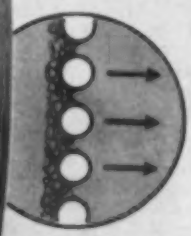

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the best type of decline difficult, a statistical approach using the method of least squares is usually employed. The case exhibiting minimum deviation is selected as most representative. When the correct decline curve has been established, the appropriate equations for $t_a$ and $Q_a$ can be used to estimate the anticipated production up to abandonment.

## FIELD EXAMPLE

A lease consists of eight wells producing at an operating cost of $1730 per month. With the value of crude oil at $3.00 per bbl, the economic limit for this lease is 577 bbl per month. These wells were put into production in June 1957 and have produced continuously since that time. Their overall production history is summarized below.

| | | $q_t$, rate bbl/mo | $Q_t$, cumulative production, bbl |
|---|---|---|---|
| 1957, | June | 3976 | 3,976 |
| | July | 4231 | 8,207 |
| | August | 4265 | 12,472 |
| | September | 3741 | 16,213 |
| | October | 3698 | 19,911 |
| | November | 3370 | 23,281 |
| | December | 4038 | 27,319 |
| 1958, | January | 3615 | 30,934 |
| | February | 3046 | 33,980 |
| | March | 2801 | 36,781 |
| | April | 3008 | 39,789 |
| | May | 2953 | 42,742 |
| | June | 2975 | 45,717 |
| | July | 3120 | 48,837 |
| | August | 2946 | 51,783 |
| | September | 2584 | 54,367 |
| | October | 2423 | 56,790 |
| | November | 2202 | 58,992 |
| | December | 2266 | 61,258 |
| 1959, | January | 2176 | 63,434 |
| | February | 1854 | 65,288 |
| | March | 2086 | 67,374 |
| | April | 2078 | 69,452 |
| | May | 2127 | 71,579 |
| | June | 1964 | 73,543 |

Using this information, determine which type of decline curve can best be used to represent these data, and estimate the total production and the time when the economic limit will be reached.

**A. Constant percentage decline.** In accordance with Equation 3, a plot of log $q_t$ vs t in months should produce a straight line if the constant percentage decline case applies. The data for this field have been plotted in this manner in Fig. 1. Using the method of least squares, a straight line has been fitted to the data, as shown. For this line, the slope, log $(1-D) = -0.01475$ and the intercept, log $q_0 = 3.64628$. From these values D is calculated to be 0.0334 per month and $q_0 = 4429$ bbl per month.

This straight line appears to represent the field data fairly well, although a certain amount of scatter exists. To characterize this scatter, the sum of the squares of the deviations of the actual rates from those predicted by the straight line has been determined to be, $\Sigma[\Delta q_t]^2 = 1{,}195{,}390$.

**B. Harmonic decline.** Equation 8 indicates that a plot of log $q_t$ vs $Q_t$ should produce a straight line if the harmonic decline case is applicable to the field data. These data have been plotted in this manner, to give Fig. 2. Using the method of least squares, a straight line has been fitted to the observed data. For this line, the slope, $-D_0/2.303q_0 = -5.07 \times 10^{-6}$ and the intercept, log $q_0 = 3.67438$. The intercept gives a value of $q_0 = 4725$ bbl per month, which can be substituted into the expression for the slope to produce $D_0 = -0.05517$ per month. This value now enables Equation 7 to be used for the calculation of the expected monthly rates of production.

The resulting straight line has been plotted on Fig. 3, along with the actual data. This straight line appears to represent the field data reasonably well with some scatter. To represent this scatter, the sum of the squares of the deviations of the actual rates from those predicted by the straight line has been determined to be $\Sigma[\Delta q_t]^2 = 1{,}512{,}310$.

**C. Hyperbolic decline.** Equation 11 indicates that a plot of log $q_t$ versus log $(1 + sD_0t)$ should produce a straight line, if the hyperbolic decline case applies. However, the value of the quantity $sD_0$ must first be established. Several values of $sD_0$ were assumed and used in fitting the production data to a straight line. Based on this analysis, the value of $sD_0 = 0.0138$ was selected as best representing the data. Using $sD_0 = 0.0138$, the experimental data have been plotted to give Fig. 4.

By the method of least squares, a straight line has been fitted to the observed data. For this line, the slope, $-1/s = -2.8852$ and the intercept, log $q_0 = 3.65681$. The intercept

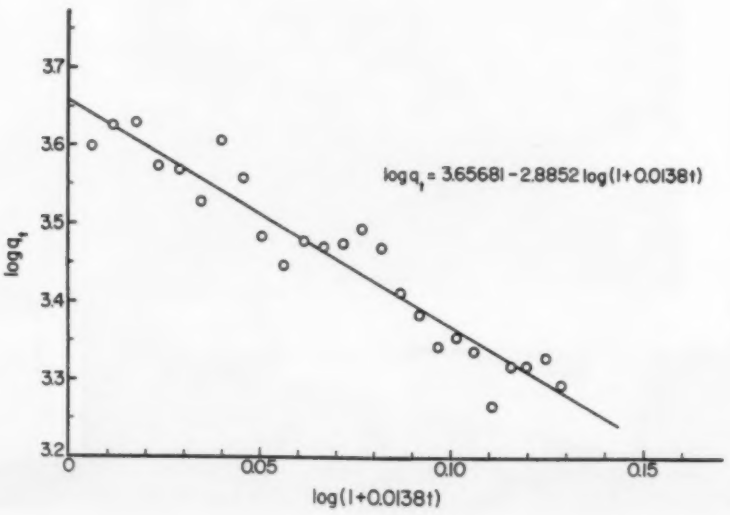


FIG. 4. **Production rate data fitted to a hyperbolic decline curve ($sD_0 = 0.0138$).**

corresponds to a value of $q_0 = 4537$ bbl per month and the slope to a value of $s = 0.3466$, which can be used to determine $D_0 = 0.03982$. To represent the scatter of the data from the straight line, the sum of the squares of the deviations of the actual rates from those predicted by the straight line has been determined to be $\Sigma[\Delta q_t]^2 = 1{,}255{,}390$.

**D. Selection of decline curve.** The following values of the sum of the squares of the deviations of the actual rates from those predicted by the different decline curves have been obtained:

| | $\Sigma[\Delta q_t]^2$ |
|---|---|
| Constant Percentage Decline | 1,195,390 |
| Harmonic Decline | 1,512,310 |
| Hyperbolic Decline | 1,255,390 |

Based on these results, the constant percentage decline curve appears to fit the production data best. However, it is only slightly better than the hyperbolic decline curve, and it is difficult to make a definite selection. The constant percentage decline curve gives a more conservative estimate of reserves, while the hyperbolic decline curve tends to give a more optimistic value. To provide a reasonable estimate, the results of both types of decline have been used to calculate reserve estimates which can be considered as limiting values.

**E. Calculation of reserve estimates.** The economic limit for this lease has been indicated to be $q_a = 577$ bbl per month. For constant percentage decline, $q_0 = 4429$ bbl per month. Therefore, it follows from Equation 5 that $r = 4429/577 = 7.6759$ and that the abandonment time is

$$t_a = -\frac{\ln r}{\ln(1-D)} = -\frac{2.303 \log 7.6759}{2.303 \log 0.9666} = 59.8 \text{ months.}$$

Similarly, Equation 6 gives the production at abandonment time:

$$Q_a = q_0 t_a \frac{r-1}{r \ln r} =$$

$$4429(59.8)\frac{7.6759 - 1}{7.6759(2.303)\log 7.6759} =$$

112,500 bbl

For hyperbolic decline, $q_0 = 4537$ bbl per month, and therefore $r = 4537/577 = 7.8631$. Since $s = 0.3466$, the abandonment time, from Equation 13, becomes

$$t_a = \frac{r^s - 1}{sD_0} = \frac{7.8631^{0.3466} - 1}{0.0138} = \frac{2.0437 - 1}{0.0138} = 75.6 \text{ months.}$$

Similarly, Equation 14 gives the production at abandonment time:

$$Q_a = q_0 t_a \left(\frac{s}{1-s}\right)\frac{1 - r^{s-1}}{r^s - 1} =$$

$$4537(75.6)\left(\frac{0.3466}{1-0.3466}\right)\frac{1 - 7.8631^{-0.6534}}{7.8631^{0.3466} - 1} =$$

133,000 bbl.

The best selection for total reserves is somewhat uncertain, but it is reasonable to expect the actual total production at abandonment to lie somewhere between 112,500 and 133,000 barrels.

**ABOUT THE AUTHORS**

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G. Thodos

William F. Stevens is associate professor of chemical engineering at Northwestern University and received his BS degree in chemical engineering from that school in 1944. He was granted a PhD degree from the University of Wisconsin in 1949. He spent two and one-half years with the B. F. Goodrich Company as a research engineer before leaving to enter the teaching profession. He is actively engaged in teaching and research in the field of process dynamics. Among his technical affiliations are the American Chemical Society and the American Institute of Chemical Engineers.

George Thodos, chairman of the department of chemical engineering at Northwestern University, received his BS and MS degrees from the Armour Institute of Technology and his PhD degree in 1943 from the University of Wisconsin. During five years with the Phillips Petroleum Company and the Pure Oil Company, he was active in research and development, engineering design, and technical evaluation of patent applications. Joining Northwestern University in 1947, he has been primarily interested in teaching and graduate research. He holds seven U. S. patents and is a member of the American Chemical Society, the American Institute of Chemical Engineers, and numerous other technical fraternities.


## Acknowledgment

Due recognition is extended to the Pure Oil Company, under whose auspices this work was carried out.


## Nomenclature

$\alpha$ proportionality constant

D instantaneous decline rate, $-\frac{dq_t/dt}{q_t}$

$D_0$ initial decline rate

$q_a$ production rate at abandonment, bbl/month

$q_0$ initial production rate, bbl/month

$q_t$ production rate at time t, bbl/month

$Q_a$ cumulative production at abandonment, bbl

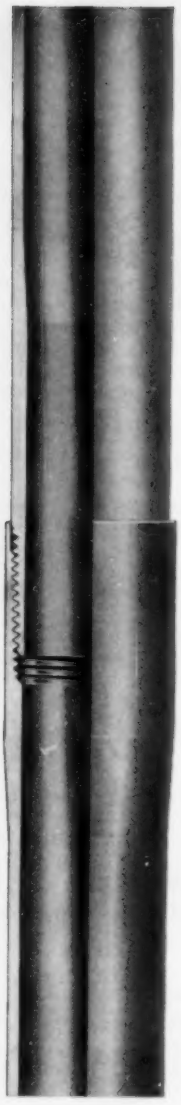
$Q_t$ cumulative production up to time t, bbl

r production rate ratio, $q_0/q_a$

s exponent, $0 \leqslant s \leqslant 1$

t time, months

$t_a$ abandonment time, months



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# BACTERIA IN FLOOD WATER:

## *What they are—What they mean*

**J. M. SHARPLEY,** *Chief Microbiologist, Petroleum Section, Buckman Laboratories, Inc., Memphis, Tennessee.*

**Ever see a microbiological report on your flood water? These reports can be confusing. What do they mean and what are the "bugs" they list? Here's an explanation of what it's all about.**

EVER LOOK at a glass full of a "sample" of water to be used in a waterflood? When it is turbid or black, as it frequently is, trouble may be expected. However, it may look perfectly clear . . . you can't see a thing in it. The filters are doing a good job. It looks great. But, months and even weeks later, the filters are all clogged up, injection pressures go up. Why?

Next time look at that water under a powerful microscope and chances are you'll find an amazing picture. You might see small translucent squirmy "bugs" that you can't detect with the naked eye. How can these minute organisms foul up your filtering and injection program? Though tiny as they might appear, those microscopic "bugs" can and do block the passage of water through filter packs and formation pores. They can also be responsible for severe corrosion problems.

So, you take a sample of the floodwater to the laboratory for examination. Back comes the report. "30,000 *Desulfovibrio desulfuricans* per milliliter," says the report. To the average producer this information might just as well be written in Latin. But proper interpretation of these data can be very helpful.

We know that there are a number of bacteria types that impair a waterflood by corrosion and by clogging. The type of "bug" or bacteria gives us a definite idea as to what should be done. The number or concentration of these bacteria will indicate how severe the problem might be and perhaps indicate the extent of treatment, if treatment is required.

We know of no way to determine that a given number of bacteria will cause damage in a waterflood reservoir without other information about the characteristics of the flood. It is our opinion that no satisfactory inter-

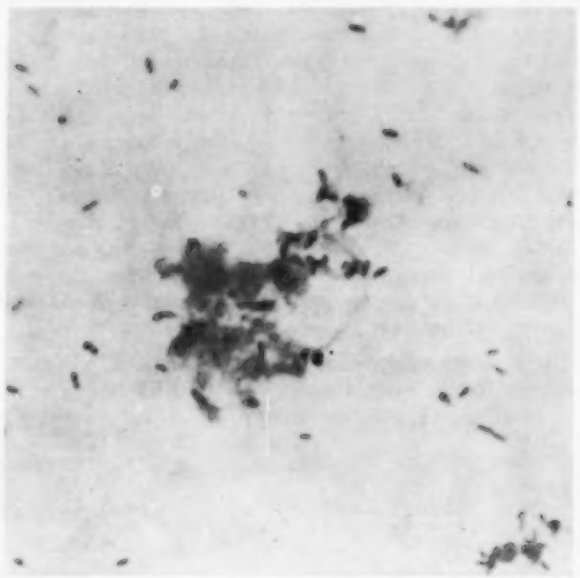

FIG. 1. **Clumps, chains or agglomerations of microorganisms** such as illustrated above can cause inaccurate plate counts. This photomicrograph shows bacteria as they grow on a solid surface.

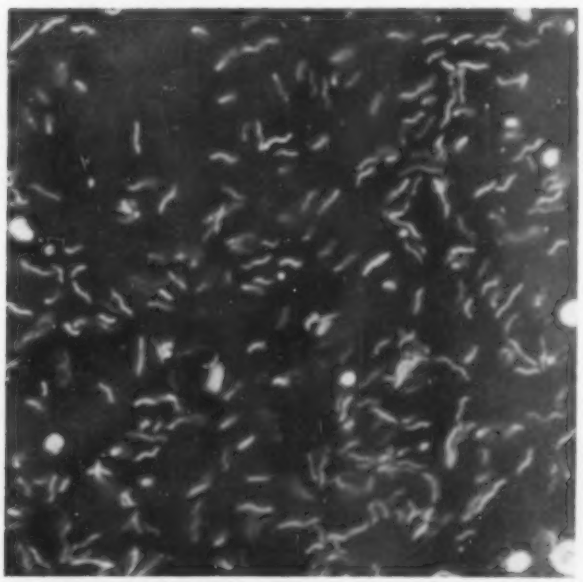

FIG. 2. **Sulfate-reducing bacteria** in connate water. The white cells are shown against a dark contrasting background. Sulfates are reduced to hydrogen sulfide.

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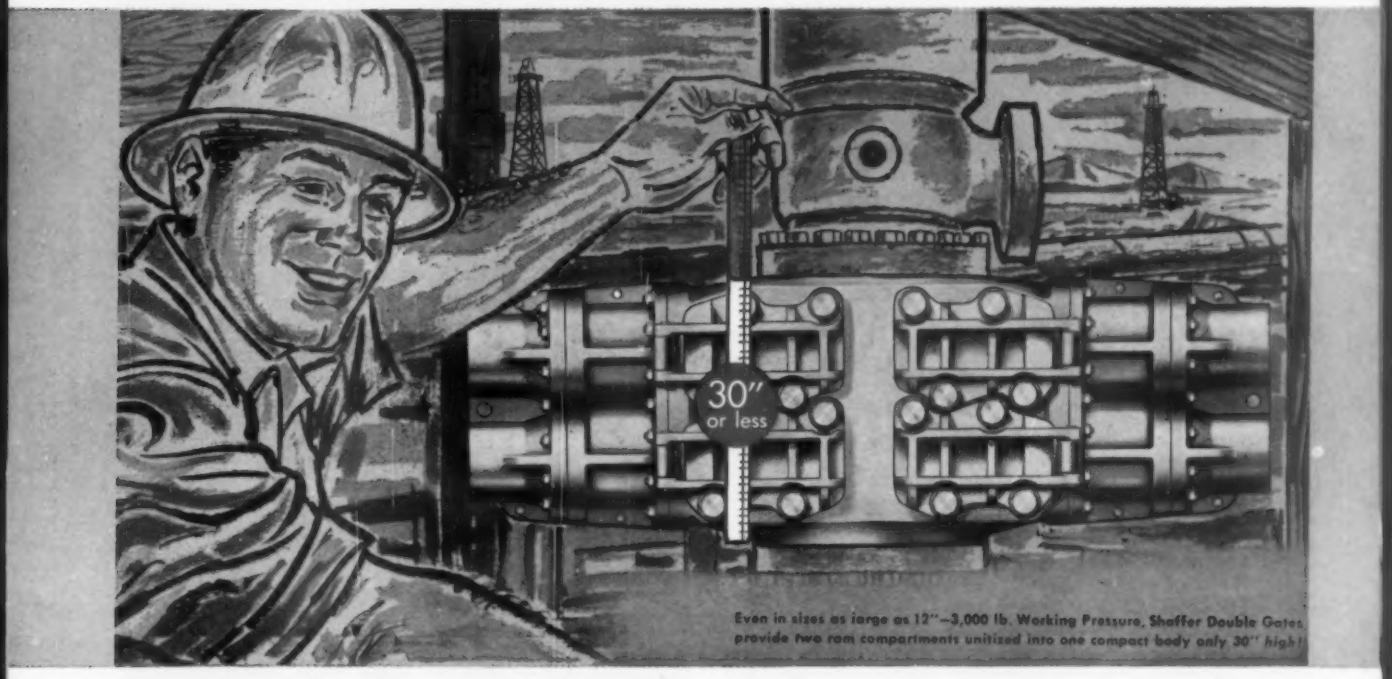
3. ***Most Shaffer Preventers are available, not only in Single Gate designs, but also in Double Gate designs—two separate ram compartments unitized into one compact, space-saving body that eliminates need for spools and extra connecting flanges.***

**RESULT:** You make important *multiple* savings in vertical height requirements when you specify Shaffer Blowout Preventers!

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pretation of microbiological data can be made without corollary information concerning the water-handling facilities, reservoir characteristics of the waterflood, and past history on performance. In other words, it is not possible to say that a count of 5000 or 10,000 bacteria per milliliter is good or bad except in a given flood where all factors are known.

The interpretation of total numerical counts of microorganisms in waterfloods is one of the common difficulties encountered in everyday operations. While it may appear reasonable to assume that a reported count of 6000 bacteria per milliliter indicates a poorer water than one having a count of 5500 bacteria per milliliter, this is not always true, because:

1. The difference in count may not be statistically significant.
2. Some of the microorganisms may not be counted for the simple reason that they will not grow on the media or under the conditions used on the test.
3. Different microorganisms have a different influence on water quality.

In order to be statistically significant, small differences in numbers must be based on a large number of determinations. Bacteria colony counts vary for many reasons, but the primary one is that we are working with a living and growing population which is constantly changing and cannot be handled in a comparable manner as the same number of inanimate particles.

**Where errors can occur.** It might be helpful to discuss briefly some of the many places where errors may occur that would markedly modify the total count of bacteria obtained from a sample of water.

1. **The sample.** The microbiological population in the water sample often depends on the manner in which it was taken. This is of particular importance to field engineers since, in many cases, they will be taking the samples. The number of bacteria present depends on whether there is air in the sample, whether the lines were flushed to remove stagnant water from nipples, whether the sampling equipment was clean, how long the sample was held before bacteriological work was started on it, and finally, the temperature and pH changes that might be involved between sampling and examination.

2. **Laboratory techniques.** The laboratory techniques used in bacteriology are many and sometimes treacherous but, for the most part, can be controlled in the laboratory. Some of the places where errors might occur are in the dispersion of the sample in the agar gel, the heat of the medium, and the actual measurement of the aliquots of sample.

3. **Factors controlling culture of the bacteria.** Probably the most important factor governing plate counts after receipt of the sample by the microbiologist is whether the technique being used for culturing a given water will actually *grow* the bacteria present in the water. Many bacteria present in water will not grow in the laboratory. There are many reasons for this failure of laboratory growth. One of these is incubation temperature. The temperature at which bacteria are being grown artificially may not be compatible with the temperature at which they grow naturally. Pressure has been an almost neglected aspect of bacteriological culture work, yet it is obviously of implied importance since most of the bacteria found in the petroleum industry characteristically grow and live under elevated pressures.

Osmotic effects and inorganic nutritional factors are important when, for example, one goes from a sample that is saturated in salt content to plating on media containing less salt.

4. **Counting or enumeration.** The whole principle behind plate counts is that a single bacterium from the sample when suspended and properly dispersed in an agar gel will start multiplying and produce a colony that can be seen with the naked eye. The colony is then counted and considered as a single microorganism in the sample. The greatest fallacy in plate counts is that many bacteria do not occur as single cells but remain as clumps, chains, or agglomerations of microorganisms. When this happens, there may be 10, 20, 30, 50, or even larger

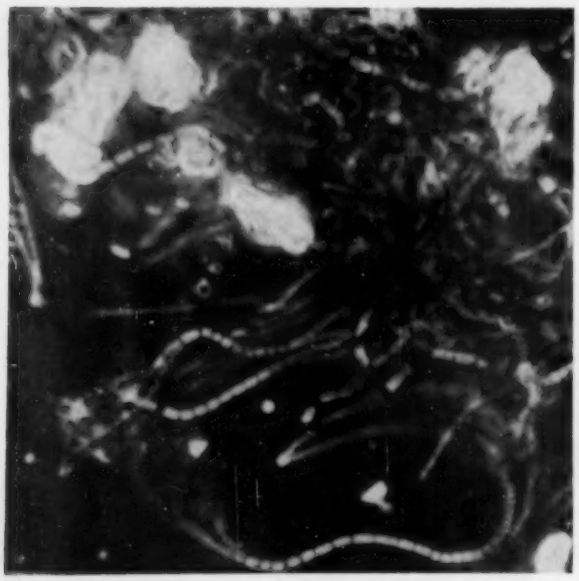

FIG. 3. **Sphaerotilus sheathed iron bacteria,** forming slime on a corrosion coupon. They occur in lines rather than in tanks or filters.

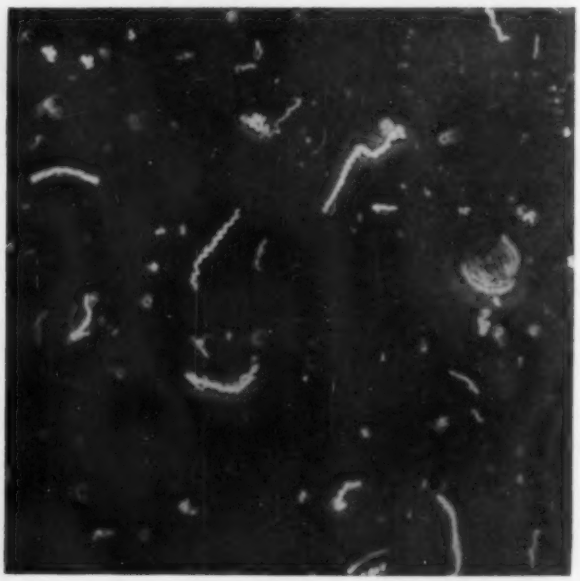

FIG. 4. **Another species of iron bacteria, Gallionella,** excretes long, twisted strands of iron oxide. The microorganism itself is rarely seen except by special cultural techniques.

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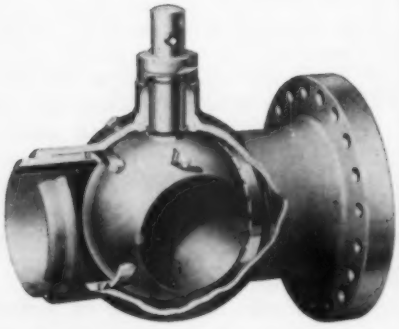

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numbers of microorganisms in a clump that will grow, producing only one colony for the entire group. This agglomeration is shown in Fig. 1. Consequently, the count is off for that percentage.

**Probable accuracies.** Some time has been spent discussing certain of the difficulties that may be encountered in making estimates of populations of bacteria simply to demonstrate that only a limited amount of reliance may be placed on one estimate of the bacterial population of a water. It is unsound to place emphasis on small differences in total bacterial colony counts. If the water is exceedingly high in bacteria, millions per milliliter, the accuracy is probably not greater than the first significant figure. Where smaller numbers of bacteria are counted, the accuracy is certainly not greater than the second significant figure.

## Effect on Permeability

Now the question that anyone concerned with treatment of waterfloods would like to have answered is: What percentage of decrease in injection will be obtained per 1000 increase of bacteria in a water? Everyone would like to know the answer to that question! The damage done by bacteria in a waterflood depends on many factors, the most important of which is probably the reservoir characteristics. To illustrate, a reservoir that has permeabilities measured in darcys may not plug from the effect of 1,000,000 or more bacteria per milliliter. On the other hand, a reservoir that has a permeability of 1 or 2 millidarcys will require the injection of very high-quality water that is essentially free of bacteria.

It is easily demonstrated that bacteria can cause plugging of a porous membrane in proportion to their number. This is an everyday problem in some industries engaged in the use of bacteria in manufacturing. It should be noted emphatically that the plugging characteristics of bacteria are not similar to the same amount of inanimate material that may be present in an injection water. The speed with which bacteria will plug a porous membrane is at least partially a function of the degree of capsulation of the bacteria. Capsules of bacteria are composed of a sticky, slimy, polysaccharide material, the secretion of which varies with the microorganisms and the environment in which they are grown. There is no such thing as a specific species of slime-forming bacteria since many bacteria may or may not form slime in the proper environment. The surface charge of bacteria also is involved in the plugging of filters and reservoirs.

Insofar as absolute numbers of bacteria are concerned, it has been shown in practice that a water containing 30,000 bacteria per milliliter will plug a reservoir that has a permeability of approximately 20 millidarcys. The API Standard RP38 recommends 10,000 bacteria per milliliter as the maximum allowable total count in injection waters. This number was chosen as an average number of bacteria that may cause difficulties in an average waterflood.

**Plugging from by-products.** There are some species of bacteria involved in waterfloods that plug primarily not because of the bacterial bodies but because of the by-products formed by the microorganisms. The common sulfate-reducing bacterium, *Desulfovibrio desulfuricans*, is one of these microorganisms and is shown in Fig. 2. In this case, the damage is done in water by the microbiological reduction of sulfates to hydrogen sulfide.

Questions often are raised in the field by engineers regarding the amount of hydrogen sulfide produced by sulfate-reducing bacteria. This question is almost unanswerable since conditions such as food, temperature, and pH in a given environment not only cause a change in the numbers of bacteria present but also cause a change in their activity.


**ABOUT THE AUTHOR**

**J. Miles Sharpley** is chief microbiologist, Petroleum Section, Buckman Laboratories, Inc., Memphis, Tennessee. He has been employed by Buckman Laboratories, Inc. since 1951. Prior to this, he worked as an industrial microbiologist in a consulting laboratory. For the past three years he has worked exclusively in petroleum microbiology, and specifically on the microbiology of secondary recovery systems. He is a native of Richmond, Virginia, and was educated at Hampden-Sydney College, The University of London, and the University of Richmond.


**Hydrogen sulfide production.** There has been some work done regarding the maximum amount of hydrogen sulfide that it is possible to produce. Where adequate nutrients are present, sulfate-reducing bacteria can produce in excess of 2000 parts per million (ppm) of hydrogen sulfide in the laboratory. Where there is a metal such as iron to react with hydrogen sulfide and remove it from solution as an insoluble sulfide, larger amounts of hydrogen sulfide can be produced.

The sulfate-reducing bacteria also can cause very severe corrosion problems. It seems probable that in most waterfloods the pit corrosion caused by sulfate-reducing bacteria is produced under deposits of slime or scale. Unfortunately, it is not known how to correlate the numbers of sulfate-reducing bacteria found in the circulating water with the numbers of sulfate-reducing bacteria that may be present in colonies on the sides of pipes.

The foregoing is part of the rationale behind the recommendation that a waterflood should be treated to the total absence of sulfate-reducing bacteria.

**Sulfur-metabolizing bacteria.** There are other sulfur-metabolizing microorganisms that occur widely in waterfloods. The sulfur-metabolizing microorganisms include bacteria that can reduce sulfates, oxidize sulfides, and oxidize sulfur. The sulfur-metabolizing bacteria other than those that reduce sulfates are not so well known in the petroleum industry, yet have potential significance. These bacteria can oxidize sulfides such as hydrogen sulfide and also can oxidize elemental sulfur.

With reference to the total number of sulfur-oxidizing bacteria that might be allowable in a waterflood, it is believed that the number should be kept at least low enough that no slime formation is present. Sufficient data are not available on waterfloods containing *Thiobacilli* to make adequate suggestions regarding the maximum number that might be allowable in a waterflood and still not impair operations.

## Iron Bacteria

The other large group of bacteria that is known to cause damage because of contributions to increases in total precipitated solids in the water is the iron bacteria. Damage from the iron bacteria in waterfloods is caused by precipitated iron and by masses of cells and slime formed by some species.

There has been more confusion about "iron bacteria" than about any of the other bacteria commonly found in waterfloods. This is partially due

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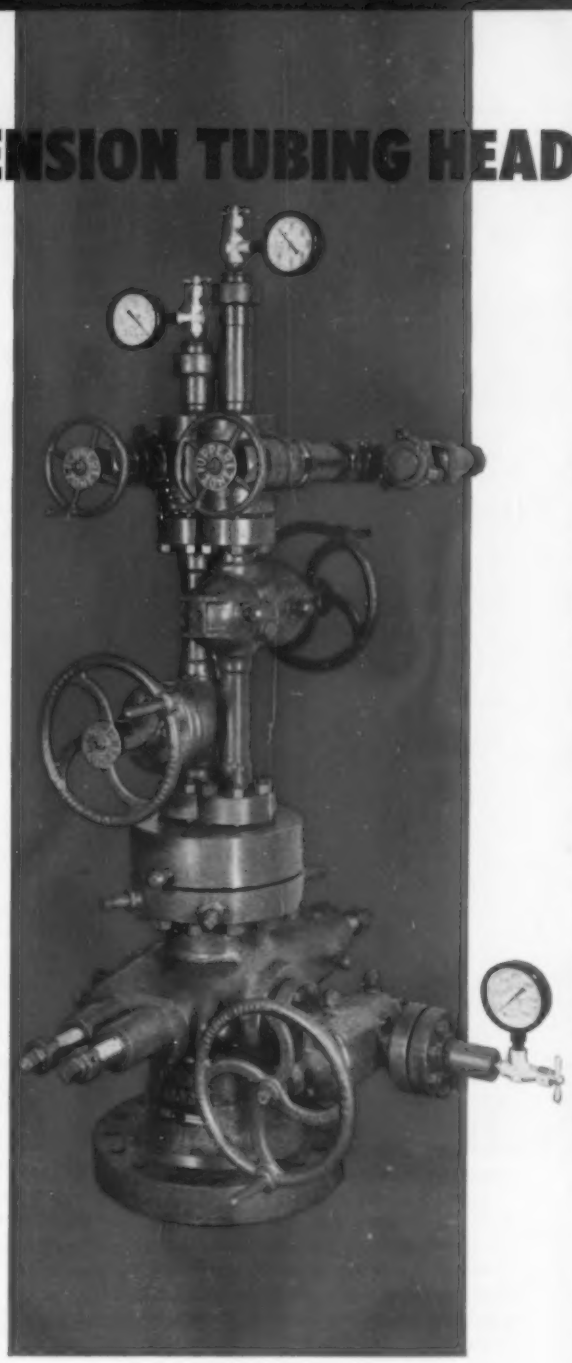

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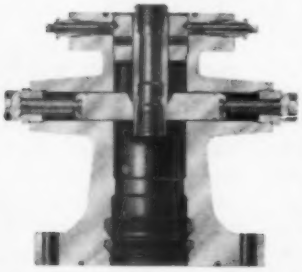

*This cutaway drawing shows the independent supporting rams and seating element of the head. The packing around the tubing hangers is tightened by tightening hold-down screws.*

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to some changes made by taxonomists in names and classifications. It seems best to separate the sheathed and stalked iron bacteria from the sulfur bacteria, but it should be recognized that some sulfur bacteria actually are formally classified as families of the same order to which iron bacteria belong.

The rather confusing classification will be dismissed and consideration will be given to the iron bacteria and the sulfur bacteria as separate groups.

**Sheathed iron bacteria.** Sheathed iron bacteria are so named because of their ability to deposit iron oxide around themselves. Some years ago, there was an attempt to classify several of these microorganisms by the manner in which the iron was deposited in the sheath. However, recent work has indicated that this is an artificial method of classification and that the names *Clonothrix* and *Leptothrix* are just other names for *Sphaerotilus*. The other apparent authentic genera of sheathed iron bacteria is *Crenothrix*, but this opinion is not shared by all investigators.

*Sphaerotilus* is a microorganism commonly found in waterfloods, but it is often not recognized. It is rather easily confused with algae as well as some other microorganisms. It commonly is found so completely buried in iron oxide deposits that the biological origin of the deposit cannot be observed without removing the iron by treatment with acid. *Sphaerotilus* is not counted or observed by the culture methods normally used in determining the microorganism populations by injection waters but can be grown on special bacteriological medium.

There is some doubt about the oxygen requirement for this specie. All of these microorganisms have been classified for many years by microbiologists as oxygen-requiring microorganisms. *Sphaerotilus* has been found in fresh water at the bottom of source wells where the oxygen tension was less than 0.2 ppm. Under these conditions, the microorganism changes its growth characteristics considerably and is inclined to form rather heavy mucoid masses with smaller than normal cells and a large amount of slime.

After the iron has been removed from a filament of *Sphaerotilus*, and after a little experience, it may be recognized readily by direct microscopic examination. The appearance of *Sphaerotilus* filaments on the surface of a membrane filter, after acid treatment to remove the iron, is sufficiently typical to be diagnostic. Prior to acid treatment, usually nothing can be detected regarding the microbiological origin of the precipitate.

*Sphaerotilus* can remove very large quantities of iron from water and deposit the material on the sides of pipes and equipment where it will contribute to physical difficulties as well as corrosion. The mechanism of iron deposition and corrosion is a little better known in the stalked iron bacteria *Gallionella* than it is in *Sphaerotilus*, but there seems to be little reason to doubt that the two are quite similar.

**Where they occur.** *Sphaerotilus* characteristically occurs in lines (see Fig. 3) rather than in storage tanks or filters. When it occurs in storage tanks or filters, it usually occurs in masses which result from slime breaking loose in the lines. This creates a great deal of difficulty, particularly in the filters. It should be noted that *Sphaerotilus* has one stage in its life history during which the microorganism is very small and should be capable of going through most filters. Thus, it may occur downstream from the filter and grow on the sides of the lines, provided environmental conditions are suitable.

*Sphaerotilus* can be kept under control by certain chemical treatments, provided they are specifically effective against the microorganisms. The author is not familiar with any type of mechanical handling arrangements that will influence the growth of this microorganism except perhaps a totally enclosed system and the use of heavy brine waters.

**Other iron bacteria.** The other iron bacteria commonly encountered in waterfloods are species of *Gallionella*. What are called *Gallionella* and actually seen microscopically (see Fig. 4) are not the microorganisms but long, twisted strands of iron oxide excreted by a small, curved rod-shaped bacterium. The bacteria are rarely seen except by special cultural techniques. Only quite recently has it been recognized that this specie is a rather prevalent microorganism in many industrial environments and, under circumstances favorable to it, can cause a great deal of difficulty in the operation of waterfloods.

Characteristically, *Gallionella* is found in large numbers in waters containing a fair amount of carbonic acid after penetrating iron-containing geologic strata. Another characteristic place to find *Gallionella* is in source wells utilizing water from either river gravel beds or old glacial fills. As an illustration of these two sources of *Gallionella*, the water from the alluvial gravel adjacent to the Arkansas River contains large numbers of *Gallionella*. They are also found in large numbers in fresh water wells drilled in the Wabash Valley basin where a glacial fill is present.

**Waterflood problems.** Difficulties caused in waterflood operations by these iron bacteria are: (1) the amount of iron precipitated from the water can be very large and can cause injection difficulties; (2) *Gallionella* may cause pronounced pit corrosion; (3) it may scale and plug the water-producing formation; (4) transfer lines and pumping equipment may be scaled and damaged by their activity.

Pit corrosion can be caused by iron bacteria establishing a cathodic cell or by creating localized anaerobic conditions that allow sulfate-reducing bacteria to grow under the iron deposits.

**Means of detection.** Iron bacteria may be detected in several ways in a waterflood but do not grow when using normal culture techniques. One of the field techniques is the observation of deposition of quantities of iron in a water system in which the oxygen content has not increased or has decreased. Another indication of iron bacteria in a waterflood system is the decrease of dissolved iron downstream.

The detection of *Gallionella* is very easy when a membrane filter is utilized. What is called *Gallionella* actually is just iron oxide; consequently, it may be dried on the surface of a membrane filter without destroying the structure. When examined microscopically, the typical twisted filaments of iron oxide can be seen easily.

It may be controlled chemically in a waterflood by injection of effective toxicants through the gravel at the source well. Injection of toxicants beyond this point in the system has achieved only partial success.

Any source water containing *Gallionella* should be treated. The microorganism is capable of too much potential damage in a short time, and it is well worth the low cost of control to avoid the risk of a system full of precipitated iron.

### Slime-Forming Bacteria

The last group of bacteria to be discussed is the often-reported "slime-forming" bacteria. This is not the proper way to identify a group of microorganisms. Whether or not most microorganisms will form slime depends upon the environmental conditions of the system. Many bacteria produce a capsule around themselves in some environments. This capsule consists of a mucoid polysaccharide material that sometimes is produced in very large quantities. This capsule material

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***See next pages for more information on Spang tubular products***

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Extreme Line casing is just part of the National Supply complete line of oil country tubular products. Spang drill pipe and National drill collars were also used in this Louisiana well.

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Both of these drill pipe products are available with SPANG Hardfacing, a superior protection for tool joints in abrasive formations. It consists of multiple bands of tungsten carbide, continuously over-lapped on the joint to form a solid particle-to-metal band.

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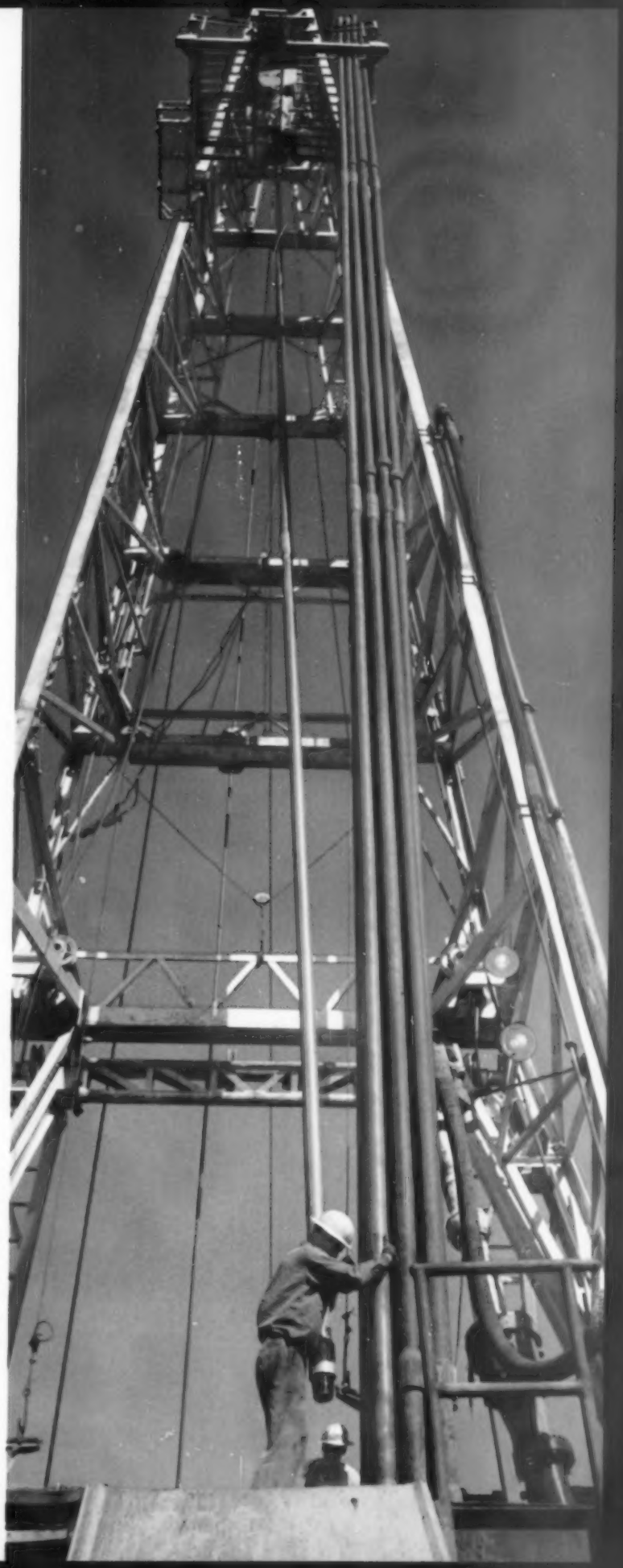

This Spang CW pipe is used in gathering lines in this California operation. The pipe has wide application in gas, oil and water gathering lines.

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acts as a cementing or bonding material in the formation of slime masses and, without question, is of primary importance in the accretion of microbiological slime. In the author's opinion, slime-forming bacteria cannot be characterized as a group separate from any other group of microorganisms. It seems best to recognize that any of the groups of microorganisms which have been mentioned can form slime under the proper environmental conditions.

If the specific environment of a given waterflood is causing slime-forming bacteria to appear, the condition should be corrected. They should not be present in any adequately treated waterflood, and any waterflood that contains an appreciable number should be treated with an effective bactericide.

### Treatments Are Beneficial

It is believed that bacterial contamination contributes much more to the economic problems of operating a waterflood than generally is recognized by operating personnel. Reduced operational and maintenance costs and improved operational efficiency are obtained by maintaining good water quality throughout the system, comparable to that leaving the filter. The following specific benefits are obtained in systems adequately treated for the control of microorganisms:

1. Improved filter operation and longer intervals between filter backwashes.
2. Control of iron sulfide resulting from the activity of sulfate-reducing bacteria and the control of precipitated iron and slime resulting from the activity of iron bacteria and other microorganisms.
3. Gradual cleaning of injection lines.
4. Control of microbiologically-induced corrosion.
5. Minimum injection well plugging with resulting reduced injection pressures, or increased injection rates, or both, depending upon the operating conditions.

The amount of difficulty caused by a given number of bacteria is a function of the specific types of bacteria involved, the kinds of bacterial plugging material which are created by the growth of these microorganisms, and the waterflood reservoir characteristics. Proper interpretation of microbiological examination of waterfloods involves consideration of all these factors.

* * *


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# new method simplifies predicting WATERFLOOD performance

H. C. SLIDER, *Associate Professor, Ohio State University, and Reservoir Engineering Consultant, Columbus, Ohio*

**Greater accuracy in prediction achieved by accounting for permeability variations, oil bank buildup and mobility variations.**

MOST OF THE PUBLISHED material on predicting waterflood performance deals with the effect of a particular parameter. Of those integrated prediction methods proposed, most have been concerned only with the total ultimate flood oil to be recovered and with little concern for the rate at which oil is recovered. To be of utmost accuracy, a method of predicting recovery rates should account for many factors, including: (1) permeability variations; (2) buildup of an oil bank when free gas is present; (3) variation in zonal mobility ratios with time; (4) variation of pattern sweep with time; and (5) variation in the saturation gradient behind the flood front.

To date, no published method has attempted to account for all of these factors. It appears that the effects of the first three are much greater than those of the last two factors. The prediction method developed herein does consider permeability variation, oil bank buildup, and mobility variation. But, it does not account for variation in sweep efficiency and the saturation gradient behind the flood front.

## Analysis of Concept

When water is injected into a reservoir which contains a variety of permeabilities, the water will advance at a rate proportional to the permeability of the various increments of thickness. If the permeability distribution is represented as the permeability distribution curve GB in Fig. 1, the advancing flood front will schematically assume this shape[1] if water is injected along EB.

We also know that if there is an initial gas saturation in the reservoir when injection is initiated, an oil bank will form in front of the water bank and there will be a definite ratio between the size of the oil bank and the size of the water bank.[2] This means that in Fig. 1 the front of the oil bank can be considered as AB which is a multiple of the water bank front GB.

By considering the producing well to be at different positions in Fig. 1 (eg. AF or KJ) an evaluation can be made of the injected fluid distribution at this time. Then, by noting the thicknesses producing water, oil, and gas at this time, the rate of oil and gas production relative to the water injection rate can be evaluated. Furthermore, based on saturations in the water bank, oil bank, and "unaffected" (gas producing) areas, fractional recovery can be evaluated.

## Distribution of Injected Water

This problem has received various treatments and is concerned with how much of the injected water enters a particular permeability zone or thickness in the reservoir under flood at a particular stage of depletion. All methods consider the distribution of the water to be primarily a function of the permeability of a particular zone as compared with the over-all permeability of the well.

In addition to the absolute permeability, the ease with which a zone accepts water is a function of the viscosity $\mu$ of the fluids flowing and the relative permeability, $K_r$. More exactly the ease with which a zone accepts water is a function of the mobility, $\lambda$ where $\lambda = \frac{K_r}{\mu}$

A zone flowing oil only will have a mobility which is different from the mobility of a zone flowing water due to the difference in relative permeabilities and viscosities. The effective mobility of a zone flowing half water and half oil will also be different. Thus, the mobility of a particular zone in a flood continually changes until it is completely flooded since there is a continual change in the over-all saturation of the zone.

At this time, the exact incorporation of a continual change in zone mobilities with time is extremely complex. This fact has led to various over simplifying assumptions by those proposing flood prediction methods. Some engineers have simply assumed no change in mobility with time.[2]

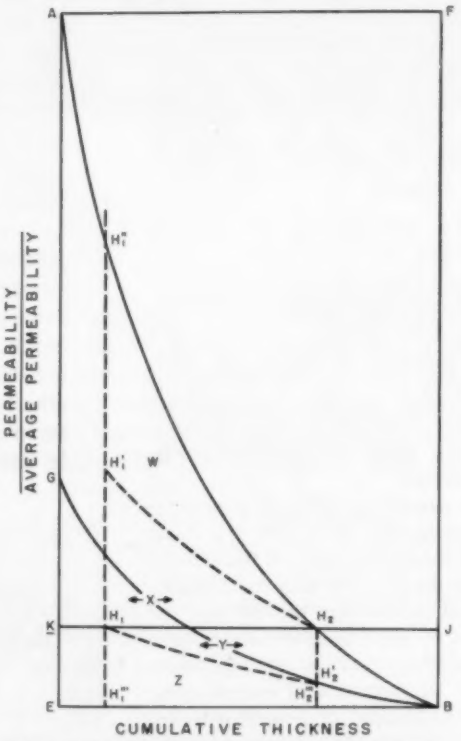
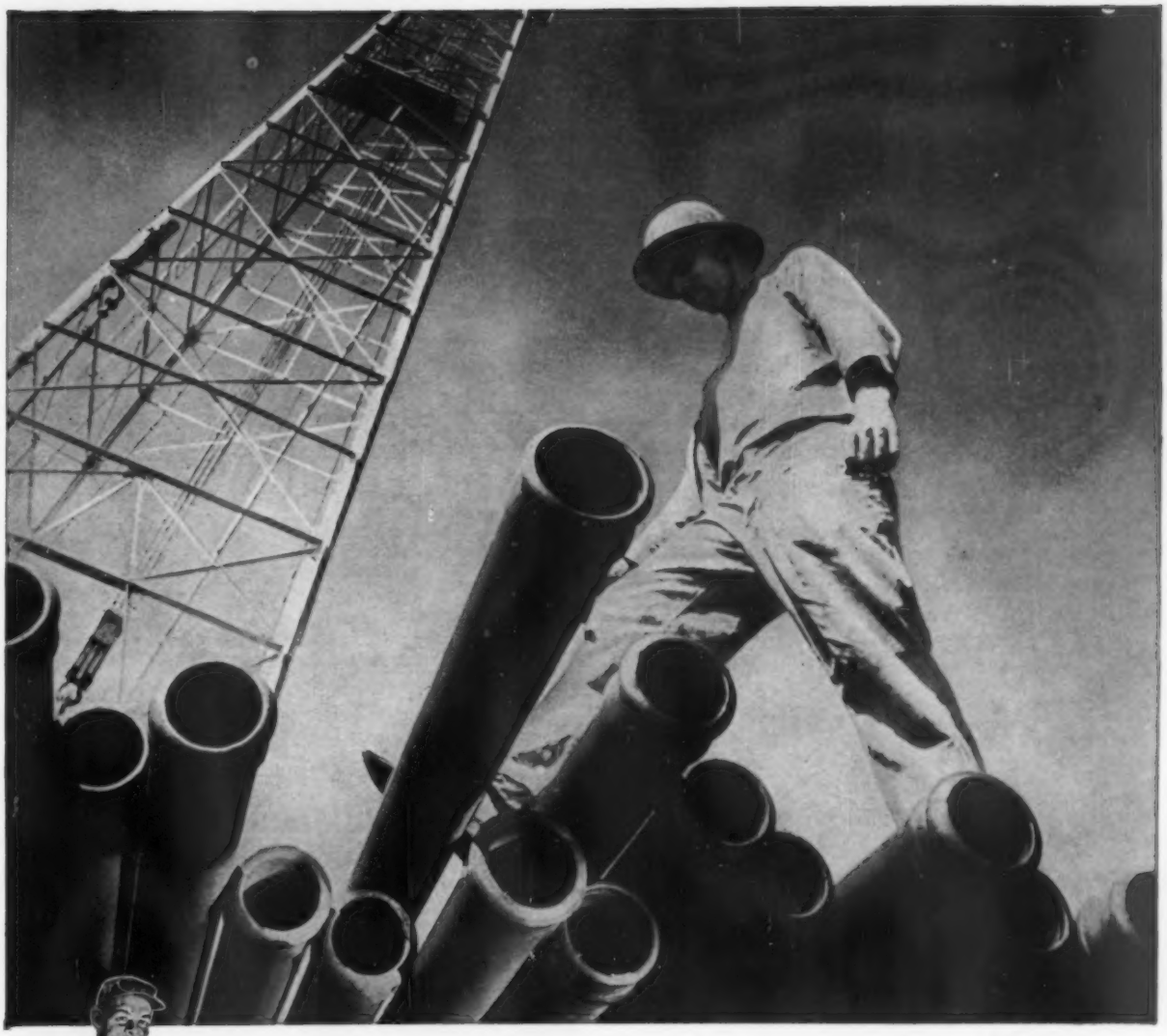



FIG. 1. **Prediction diagram** which considers permeability variations for various relative values of thicknesses.



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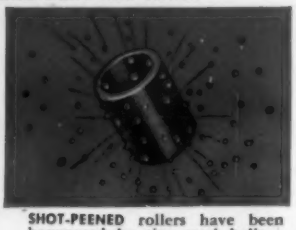

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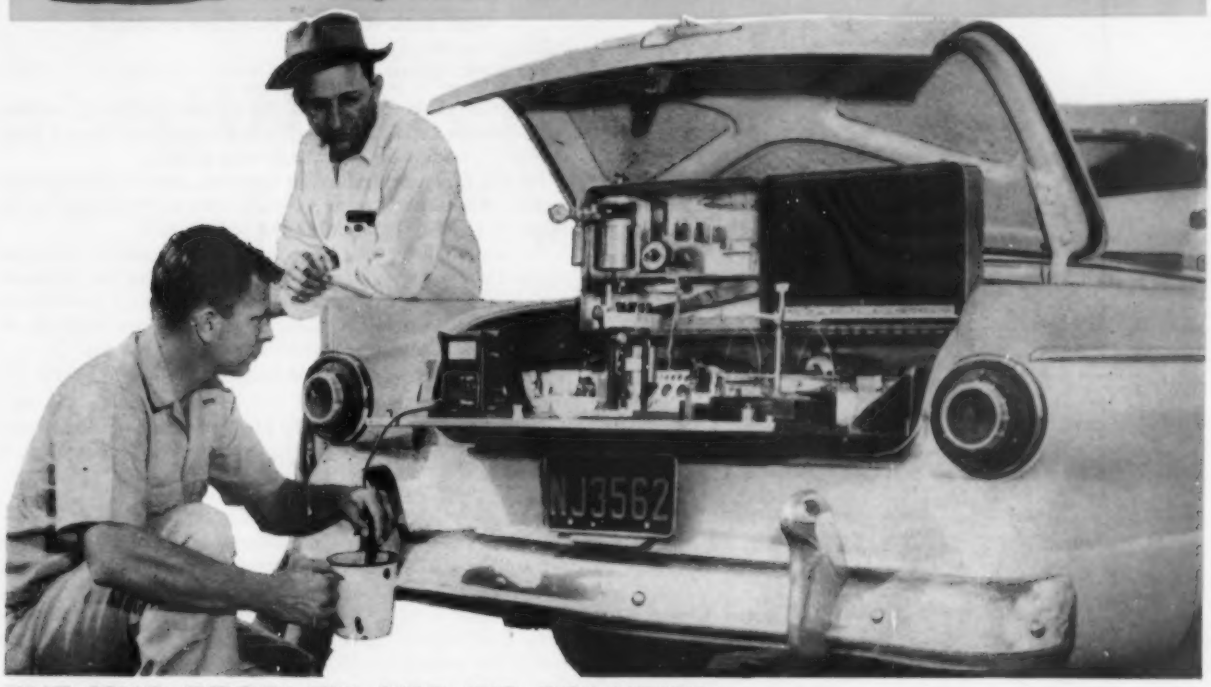


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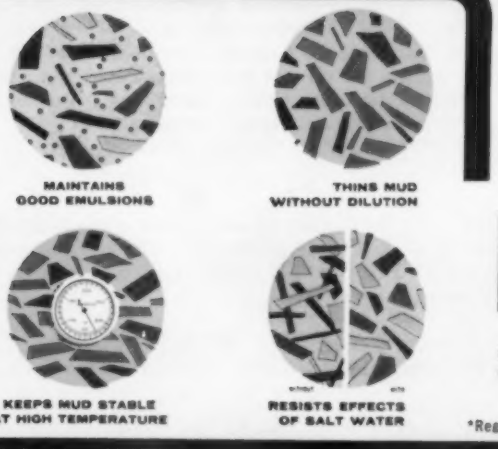
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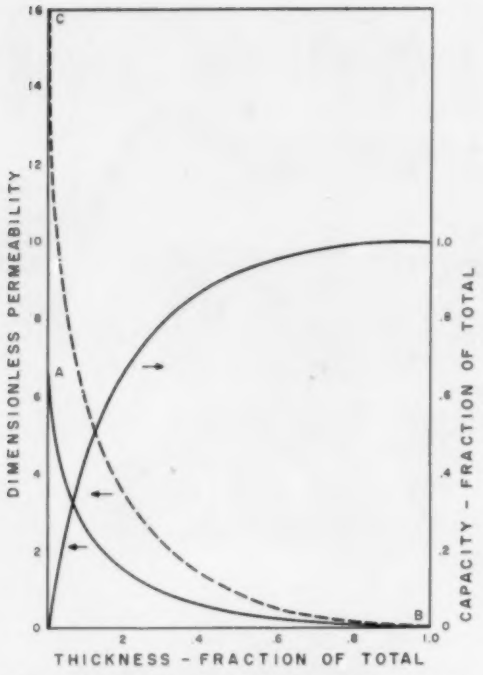


FIG. 2. **Permeability and capacity data** sample used to demonstrate application of simplified approach.

Others have assumed that the mobility is governed by the saturation of the producing well.[1] The mobility change can be much more accurately approximated.

It has been established by Muskat[4] and others that approximately 80% of the steady state pressure drop between the input and the producer in a five-spot flood takes place in about 4% of the five-spot volume near the input and 4% near the producer. Thus, flow resistance or mobility in a five-spot can be considered at only the area of the input and the area of the producer without introducing appreciable errors. The relationship between mobilities in series and the effective mobility of a zone is[5]:

$$\lambda_z = 2\left(\frac{1}{\lambda_i} + \frac{1}{\lambda_p}\right)^{-1}$$

where subscripts z, i, and p refer to zone, input, and producer respectively.

A zone in a flood that has not yet experienced an increase in oil production (unaffected) will be producing gas and will be flowing water at the input and gas at the producer. A zone producing flood oil will be flowing water at the input and oil at the producer. A zone that has been depleted of its flood oil will effectively be flowing water at the input and at the producer. The effective mobilities in these zones will then be:

$$\lambda_{gz} = 2\left(\frac{1}{K_w/\mu_w} + \frac{1}{K_g/\mu_g}\right)^{-1} \quad . \quad . \quad . \quad (1)$$

$$\lambda_{oz} = 2\left(\frac{1}{K_w/\mu_w} + \frac{1}{K_o/\mu_o}\right)^{-1} \quad . \quad . \quad . \quad (2)$$

$$\lambda_{wz} = 2\left(\frac{1}{K_w/\mu_w} + \frac{1}{K_w/\mu_w}\right)^{-1} \quad . \quad . \quad . \quad (3)$$

## Advance of the Oil and Water Fronts

If GB in Fig. 1 represents the permeability distribution, we can assume that as long as all sections of the formation have the same mobility the water bank front will assume the shape of the permeability distribution. (Consider injection along the line EB.) Since the mobile oil occupies the initial gas saturation in the oil bank:

$$\frac{\text{oil bank volume}}{\text{water bank volume}} = \frac{\text{mobile oil saturation}}{\text{initial gas saturation}}$$

calling this ratio D,

$$\text{oil bank volume} = D(\text{water bank volume}) \quad . \quad . \quad (4)$$

If curve AB is the front of the oil bank before it reaches the producer (all thicknesses have the same unaffected zone mobility), values on AB = value on GBD.

At the first oil production increase, the producing well would schematically be at AF with GBA representing the oil bank and GBE representing the water bank.

In accordance with the simplified mobility concepts derived above, movement of fluid in an increment of thickness would be slowed down whenever flood oil production from that thickness commences, since the mobility to oil will always be much less than the mobility to gas.

Now, assume a schematic well position as $\underline{KJ}$ with $H_1$ thickness producing water, $(H_2\text{-}H_1)$ producing oil and $(1\text{-}H_2)$ producing gas. If $H_1^1\,H_2$ represents the schematic front of the oil bank at this time, according to equations 4 or 5

$$H_1^1\,H_1 = (H_1H_1^{111})\,D$$

Also, if there had been no change in mobility when the streamline $H_1^{111}H_1H_1^1H_1^{11}$ started producing oil, the front of the oil bank would have moved from $H_1$ to $H_1^{11}$ during the same time period it was moving from $H_1$ to $H_1^1$. Therefore, these distances are in the same ratio as the ratio of the mobilities in the oil and gas producing sections or:

$$\frac{H_1H_1^1}{H_1H_1^{11}} = \frac{\lambda_{oz}}{\lambda_{gz}}$$

For any schematic position of the well, that thickness producing water, $\bar{H}_1$, can then be evaluated as follows:

(1) let $\underline{K}$ represent the schematic permeability position of the well.

(2) $\underline{K} + (\underline{K} \cdot D)$ = position of the oil bank front along the permeability scale.

(3) $\underline{K} + \left(\underline{K} \cdot D\,\frac{\lambda_{gz}}{\lambda_{oz}}\right)$ = position of the oil bank front along the permeability

$\underline{K}\left(1 + D\,\frac{\lambda_{gz}}{\lambda_{oz}}\right)$ = scale if there had been no mobility change.

(4) Locating this position along AB gives the thickness $H_1$ which is producing water.

## Calculating Producing Rates

Once the thicknesses producing oil, water, and gas have been established for a particular well position, it is possible to calculate the oil and water producing rate as a fraction of the injection rate. Using a cumulative fractional capacity curve as in Fig. 2 simplifies the calculation.

The total relative injection capacity will be:

$$\lambda_{wz}\,C_1 + (C_2 - C_1)\,\lambda_{oz} + (1 - C_2)\,\lambda_{gz}$$

where $C_1$ and $C_2$ refer to corresponding capacities for thicknesses $H_1$ and $H_2$. Assuming no cross flow, the production of a particular thickness will equal the injection for that thickness. Thus,

$$\frac{q_o}{q_{wi}} = \frac{(C_2 - C_1)\,\lambda_{oz}}{\lambda_{wz}C_1 + (C_2 - C_1)\,\lambda_{oz} + (1 - C_2)\,\lambda_{gz}} \quad . \quad . \quad . \quad (6)$$

$$\frac{q_w}{q_{wi}} = \frac{\lambda_{wz}C_1}{\lambda_{wz}C_1 + (C_2 - C_1)\,\lambda_{oz}} \quad . \quad . \quad . \quad (7)$$

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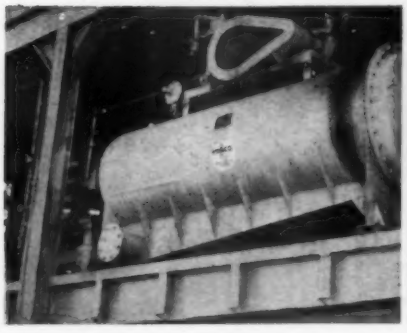

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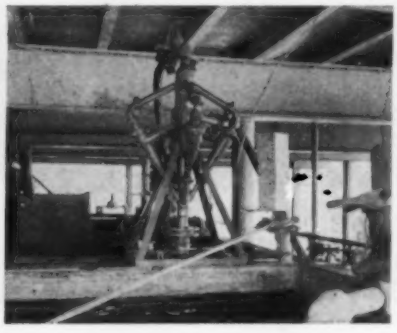

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These fractional rates, of course, change with time as represented by the schematic well position.

### Calculation of Fractional Recovery

If the saturations are known for the oil bank, water bank, and "unaffected" area, it is then possible to calculate the fraction of mobile oil recovered at a particular time represented by a particular schematic well position.

With the producer schematically at KJ the theoretical ultimate recovery will be the area ($KJB\bar{E}\cdot S_{om}$), where $S_{om}$ is the mobile oil saturation. Since BE is 1.0, the theoretical ultimate recovery will be simply $\underline{K}\ S_{om}$. Fractional recovery will then be:

$$\frac{\text{Area } \underline{K}H_2H_2^{111}E\cdot S_{om} - \text{Area Oil Bank}\cdot(S_{om}+S_{gi})}{\underline{K}\cdot S_{om}}$$

where $S_{gi}$ is the free gas saturation at the initiation of injection. Simplifying, fraction of mobile oil recovered

$$=\frac{\underline{K}H_2 - \text{Area Oil Bank}\left(1+\frac{S_{gi}}{S_{om}}\right)}{\underline{K}} \quad . \quad . \quad . \quad (8)$$

To define the oil bank area for use in Equation 8, we will consider areas w, x, y and z in Fig. 1. These areas cannot be defined individually but are interrelated through the oil and gas zone mobilities, $\lambda_o$ and $\lambda_{gi}$, and the displacement factor, D. Two areas can be stated in finite terms.

$$(Z+Y) = (H_2 - H_1)\underline{K}$$

$$(W+X+Y+Z) = (C_2 - C_1)(1+D)$$

We will define the oil bank area in terms of these two areas.

$$\text{Oil Bank Area} = Y = (Z+Y) - (Z)$$

$$Z = \frac{(X+Y+Z)}{1+D}$$

$$(X+Y+Z) = \frac{\lambda_{oz}}{\lambda_{gz}}[(W+X+Y+Z) - (Z-Y)] + (Z+Y)$$

Substituting in the expression for Z above:

$$Z = [(W+X+Y+Z) - (Z+Y)]\ \frac{\lambda_{oz}}{\lambda_{gz}}\cdot\frac{1}{1+D} + (Z+Y)\cdot\frac{1}{1+D}$$

**Table 1. Calculation of Producing Rates and Injectivity.**

| (1) $\underline{K}$ (Dimensionless) | (2) $H_2$ (Fraction) | (3) $\underline{K}\left(1+D\frac{\lambda_{gz}}{\lambda_{oz}}\right)$ | (4) $H_1$ (Fraction) | (5) $C_2$ (Fraction) | (6) $C_1$ (Fraction) | (7) Oil rate (Fraction of input) | (8) Avg. oil rate (Fraction of input) | (9) Water rate (Fraction of input) | (10) Avg. water rate (Fraction of input) | (11) Injectivity (Fraction) |
|---|---|---|---|---|---|---|---|---|---|---|
| 15.9 | 0 | 74.9 | 0 | 0 | 0 | Trace | | 0 | | 1.00 |
| | | | | | | | .0383 | | 0 | |
| 10.0 | .023 | 47.1 | 0 | .197 | 0 | .0766 | | 0 | | .87 |
| | | | | | | | .1154 | | 0 | |
| 7.0 | .070 | 33.0 | 0 | .349 | 0 | .1541 | | 0 | | .77 |
| | | | | | | | .2115 | | 0 | |
| 5.0 | .128 | 23.6 | 0 | .520 | 0 | .2689 | | 0 | | .66 |
| | | | | | | | .3088 | | 0 | |
| 4.0 | .170 | 18.8 | 0 | .612 | 0 | .3486 | | 0 | | .60 |
| | | | | | | | .3808 | | 0 | |
| 3.38 | .207 | 15.9 | 0 | .677 | 0 | .4129 | | Trace | | .56 |
| | | | | | | | .4373 | | .0049 | |
| 2.9 | .240 | 13.7 | .002 | .723 | .01 | .4617 | | .0098 | | .52 |
| | | | | | | | .4704 | | .0145 | |
| 2.7 | .257 | 12.7 | .003 | .743 | .020 | .4791 | | .0192 | | .51 |
| | | | | | | | .4866 | | .0245 | |
| 2.5 | .272 | 11.8 | .007 | .761 | .030 | .4940 | | .0298 | | .50 |
| | | | | | | | .4815 | | .0624 | |
| 2.3 | .292 | 10.8 | .016 | .783 | .095 | .4690 | | .0950 | | .50 |
| | | | | | | | .4440 | | .1460 | |
| 2.0 | .320 | 9.42 | .033 | .810 | .197 | .4191 | | .1970 | | .50 |
| | | | | | | | .3861 | | .2777 | |
| 1.5 | .385 | 7.07 | .070 | .859 | .350 | .3531 | | .3584 | | .49 |
| | | | | | | | .3038 | | .4592 | |
| 1.0 | .480 | 4.71 | .139 | .910 | .545 | .2546 | | .5601 | | .49 |
| | | | | | | | .1899 | | .6757 | |
| .5 | .620 | 2.36 | .287 | .959 | .778 | .1252 | | .7913 | | .49 |
| | | | | | | | .0880 | | .8589 | |
| .2 | .770 | .942 | 490 | .989 | .915 | .0509 | | .9265 | | .49 |

(1) Assumed producer position

(2) Read from Fig. 2

(3) $\underline{K}\left(1+D\frac{\lambda_{gz}}{\lambda_{oz}}\right) = \underline{K}\left(1+1.27\frac{2.34}{0.794}\right) = 4.71\underline{K}$

(4) Thickness at which Column 3 is located on upper curve of Fig. 2.

(5) Cumulative capacity at $H_2$

(6) Cumulative capacity at $H_1$

(7) $$\frac{\lambda_{oz}(C_2-C_1)}{\lambda_{wz}C_1 + \lambda_{oz}(C_2-C_1) + \lambda_{gz}(1-C_2)} = \frac{0.794\,(C_2-C_1)}{1.17C_1 + 0.794\,(C_2-C_1) + 2.34\,(1-C_2)}$$

(8) $$\frac{\text{Column } (7)_n + \text{Column } (7)_{n+1}}{Z}$$

(9) $$\frac{\lambda_{wz}C_1}{\lambda_{wz}C_1 + \lambda_{oz}(C_2-C_1) + \lambda_{gz}(1-C_2)} = \frac{1.17C_1}{1.17C_1 + 0.794\,(C_2-C_1) + 2.34\,(1-C_2)}$$

(10) $$\frac{\text{Column } (9)_n + \text{Column } (9)_{n+1}}{2}$$

(11) $$\frac{\lambda_{wz}C_1 + \lambda_{oz}(C_2-C_1) + \lambda_{gz}(1+C_2)}{\lambda_{gz}} = \frac{1.17C_1 + 0.794\,(C_2-C_1) + 2.34\,(1-C_2)}{2.34}$$

Substituting for Z in the Oil Bank Area expression:

$$\text{Oil Bank Area} = (Z + Y) - [(W + X + Y + Z) - (Z + Y)]\frac{\lambda_{oz}}{\lambda_{gz}} \cdot \frac{1}{(1 + D)} - (Z + Y) \cdot \frac{1}{(1 + D)}$$

Substituting in terms of $\underline{K}$, D, thicknesses and capacities for $(Z + Y)$ and $(W + X + Y + Z)$ as above:

$$\text{Oil Bank Area} = (H_2 - H_1)\,\underline{K} - \left[(C_2 - C_1)(1 + D) - (H_2 - H_1)\,\underline{K}\right]\frac{\lambda_{oz}}{\lambda_{gz}} \cdot \frac{1}{(1 + D)} - (H_2 - H_1)\,\underline{K} \cdot \frac{1}{(1 + D)}$$

$$= \underline{K}\,(H_2 - H_1)\left[1 - \frac{1 - \frac{\lambda_{oz}}{\lambda_{gz}}}{1 + D}\right] - (C_2 - C_1)\frac{\lambda_{oz}}{\lambda_{gz}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

When this expression is divided by $\underline{K}$, the Oil Bank Area becomes a fraction of the flood area.

Using the oil bank area in Equation 8 makes possible the evaluation of the fractional recovery at each schematic position of the producing well. When combined with the evaluation of the oil and water producing rates for each schematic well position it will be seen that the complete flood history can be described.

## Sample Calculation

Given: Permeability distribution as in Fig. 2 (solid curve)
Total mobile oil in reservoir at start of flood = 247,000 bbl
Total free gas in reservoir at start of flood = 194,000 bbl
Relative permeability to water at residual oil saturation = .7
Relative permeability to oil at connate water saturation = .6
Relative permeability to gas at initial gas saturation = .5
Fluid viscosities at reservoir conditions: water = .6 cp, oil = 1.0 cp, and gas = .017 cp.

Field injection rate = 6000 bbl per month.

Permeability and saturation data used in this example were obtained from a statistical analysis of a portion of an

**Table 2. Calculation of Recovery and Cumulative Injection.**

| (1) $\underline{K}$ | (2) Oil bank | (3) | (4) OIL RECOVERY | (5) | (6) Avg. oil rate | (7) INJECTION | (8) |
|---|---|---|---|---|---|---|---|
| (Dimensionless) | (Fraction of flood) | (Fraction of mobile) | (Cum. Bbl.) | (Δ Bbl.) | (Fraction of input) | (Δ 1000 Bbl.) | (Cum. 1000 Bbl.) |
| | | | | | | 27.7 | |
| 15.9 | .0 | .0 | 0 | | | | 27.7 |
| | | | | 1483. | .0383 | 38.7 | |
| 10.0 | .0096 | .006 | 1483. | | | | 66.4 |
| | | | | 1483. | .1154 | 12.8 | |
| 7.0 | .0327 | .012 | 2966. | | | | 79.2 |
| | | | | 4201. | .2115 | 19.9 | |
| 5.0 | .0552 | .029 | 7167. | | | | 99.1 |
| | | | | 4448. | .3088 | 14.4 | |
| 4.0 | .0685 | .047 | 11615. | | | | 113.5 |
| | | | | 4943. | .3808 | 13.0 | |
| 3.38 | .0784 | .067 | 16558. | | | | 126.5 |
| | | | | 5189. | .4373 | 11.9 | |
| 2.9 | .0848 | .088 | 21747. | | | | 138.4 |
| | | | | 2471. | .4704 | 5.3 | |
| 2.7 | .0889 | .098 | 24218. | | | | 143.7 |
| | | | | 4202. | .4866 | 8.6 | |
| 2.5 | .0880 | .115 | 28420. | | | | 152.3 |
| | | | | 1976. | .4815 | 4.1 | |
| 2.3 | .0943 | .123 | 30396. | | | | 156.4 |
| | | | | 4943. | .4440 | 11.1 | |
| 2.0 | .0990 | .143 | 35339. | | | | 167.5 |
| | | | | 12357. | .3861 | 32.0 | |
| 1.5 | .1073 | .193 | 47696. | | | | 199.5 |
| | | | | 19275. | .3038 | 63.4 | |
| 1.0 | 1170 | .271 | 66971. | | | | 262.9 |
| | | | | 36822. | .1899 | 193.9 | |
| .5 | .1120 | .420 | 103793. | | | | 456.8 |
| | | | | 53379. | .0880 | 606.6 | |
| .2 | .0750 | .636 | 157172. | | | | 1063.4 |

Note: Thicknesses and capacities ($H_1$, $H_2$, $C_1$, $C_2$) are read from Table 1 for appropriate $\underline{K}$.

(1) Same as Column 1, Table 1

(2) $= \left[1 - \frac{1 - \left(\frac{\lambda_{oz}}{\lambda_{gz}}\right)}{D + 1}\right]\underline{K}\,(H_2 - H_1) - \frac{\lambda_{oz}}{\lambda_{gz}}(C_2 - C_1) \times \frac{1}{\underline{K}}$

$= \frac{0.71\,\underline{K}\,(H_2 - H_1) - 0.342\,(C_2 - C_1)}{\underline{K}}$

(3) $H_2$ – Oil Bank Fraction $\left(1 + \frac{1}{D}\right)$
$= H_2$ – Column (11) 1.789

(4) Column 3 × Total Mobile Oil
= Column 3 × 247,127

(5) Column $4_n$ – Column $4_{n-1}$

(6) From Table 1, Column (8)

(7) $\frac{\Delta \text{ Recovery}}{\text{Avg. Oil Rate}} = \frac{\text{Column 5}}{\text{Column 6}}$

(8) = Σ Column (7)

*Cumulative injection at first oil increase

$= \frac{1 + D}{\underline{K}}\left(\frac{\text{Bbl of}}{\text{Gas Sat.}}\right) = \frac{2.27}{15.9} \times 194{,}000$

actual field. Production data were insufficient for consideration of the entire field. The relative permeability and viscosity data were taken from typical published data. The injection rate is believed to be a reasonable assumption for this formation.

The displacement ratio D is calculated by dividing the mobile oil saturation by the gas saturation

$$D = \frac{S_{om}}{S_{gi}} = \frac{247{,}000}{194{,}000} = 1.27$$

The dotted line in Fig. 2 is then calculated by multiplying permeability values in the permeability distribution curve by $1 + 1.27 = 2.27$. For example, at a thickness of 0.1 the permeability on the permeability distribution curve is 2.6. The value on the dotted curve will be observed to be $2.6 \times 2.27 = 5.9$.

The cumulative capacity curve is calculated by standard methods and represents:

$$\text{Fractional Capacity} = \sum_{0}^{\text{Subject Thickness}} \text{Dimensionless Permeability} \cdot \Delta \text{Fractional Thickness}$$

This curve is also plotted in Fig. 2.

Calculations of the mobilities of the gas producing, oil producing and water producing thicknesses are calculated according to Equations 1, 2, and 3 as follows:

$$(1)\ \lambda_{gz} = 2\left[\frac{1}{0.5/0.017} + \frac{1}{0.7/0.6}\right]^{1} = 2.34$$

$$(2)\ \lambda_{oz} = 2\left[\frac{1}{0.5/1.0} + \frac{1}{0.7/0.6}\right]^{-1} = 0.79$$

$$(3)\ \lambda_{wz} = 2\left[\frac{1}{0.7/0.6} + \frac{1}{0.7/0.6}\right]^{-1} = 1.17$$

With these values calculated, we can proceed with the tabular calculations in Table I. These calculations are performed by assuming a $\underline{K}$ position of the schematic producer in Fig. 2 and calculating the oil production rate, water production rate, and cumulative recovery for this well position. Then, dividing the recovery between well positions by the average oil rate between well positions the $\Delta$ time interval between schematic well positions is obtained.

Certain critical schematic well positions should be noted. The first oil increase comes when $\underline{K}$ equals the dotted line permeability value for zero thickness which in our example is 15.8. Our outlined procedure for relating rates to time will not apply previous to this schematic well position since no flood oil rate exists at this time. However, the time to first flood oil production can be calculated by evaluating cumulative injection at this time. All of the gas space under the dotted curve has been filled at this time. Since the area under the permeability distribution curve is the total capacity which equals 1.0, the area under the dotted curve is $1.0 \times (1 + D)$. The schematic reservoir volume at this well position is $15.9 \times 1.0$ and,

$$\text{Cumulative injection at first flood oil production} = \frac{2.27}{15.9} \times \text{total initial gas saturation}$$

$$= \frac{2.27}{15.9} \times 194{,}000$$

$$\text{Time to first flood oil production} = \frac{2.27}{15.9} \times 194{,}000 \times \frac{1}{6000}$$

$$= 4.6 \text{ months}$$

The resulting oil production rate vs time is plotted in Fig. 3. Engineers familiar with field flood performance in primary depleted reservoirs will note the close similarity between the calculated performance and that experienced in actual floods. The general shape of the oil and water production rate curve, the peak oil rate equal to about half the injection rate, and the oil and water rates crossing shortly after the peak oil production, are typical of actual flood results.

Also note the typical variation in relative injectivity during the predicted flood life. This is obtained by observing the relative injectivity in Column 11 of Table 1. This is a comparison of the total mobility to the mobility in the gas-producing zone. At the start of the flood, relatively little difficulty may be experienced with injection, but as the oil rate increases, the relative injectivity decreases. Eventually, these injection difficulties level off as a large fraction of the reservoir is flowing water. In the very late stage of the flood, there actually will be small increases in the injectivities. The tendency is indicated in Column 11 of Table 1.

Since the actual flood was extremely out of balance on an injection basis, it was impossible to compare predicted and actual flood performance of the unit studied. However, to provide some comparison of predicted and actual performance, published total field flood results are indicated with the injection rate adjusted to a daily rate comparable to that of the unit. The actual peak oil rate came late and was low as would be expected of a flood in poor injection balance.

The method was also applied to the example data of Prats paper with oil rate results as indicated in Fig. 4. Apparently only a small difference in this field's initial gas saturation would result in a shift of the predicted curve to the left. The predicted and actual results would then be virtually identical.

**Nomenclature**

$\lambda$ = mobility = $\left(\frac{K}{\mu}\right)$
K = permeability
$\mu$ = viscosity
H = thickness
C = capacity = $(\Sigma\, KH)$
D = ratio between oil bank and water bank = $\frac{\text{oil bank volume}}{\text{water bank volume}}$
q = flow rate
S = saturation

**Subscripts**

o = oil
g = gas
i = injection or at injection well
p = at producer
z = zone
w = water
wi = water injection
om = mobile oil
gi = initial gas

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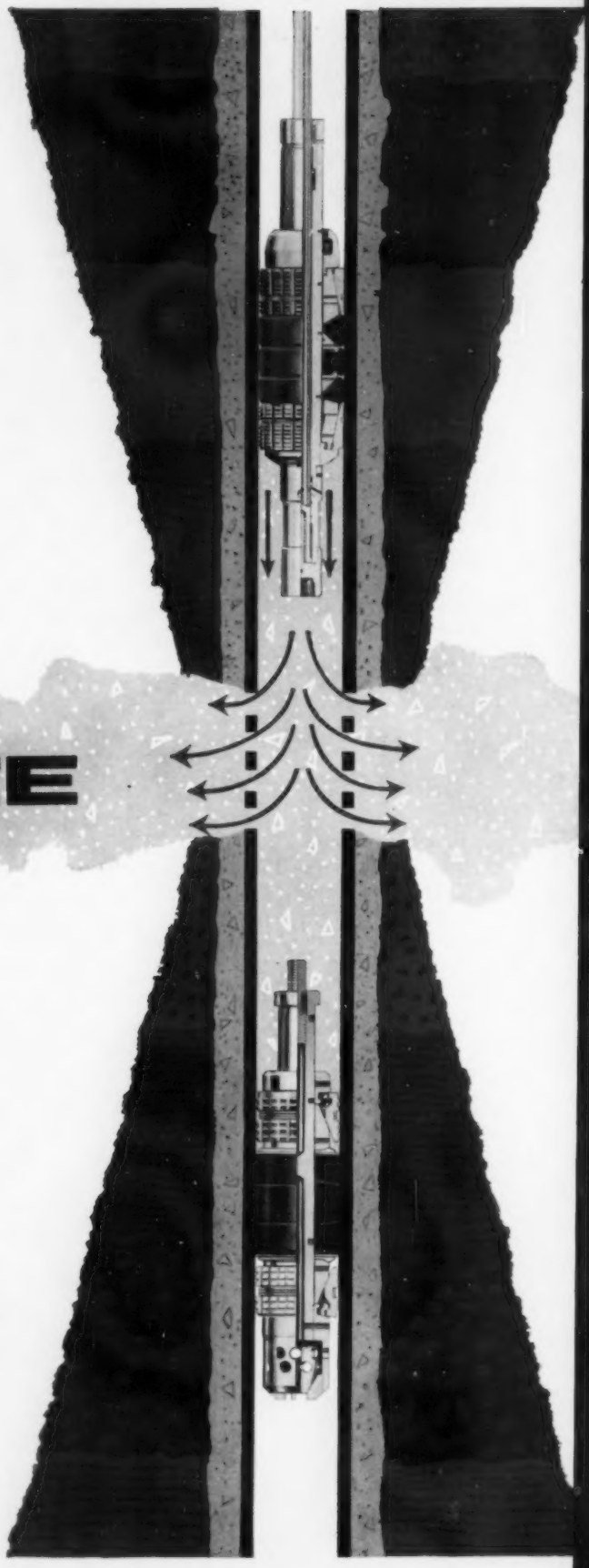
## Acknowledgment


Many of the mathematical manipulations involved in this prediction method were developed by Anthony Francis Altamira in his M.S. thesis[6] at the Ohio State University. He is presently with the Texaco Production Research Company in Houston, Texas. Kent Shepherd, a Petroleum Engineering student at the Ohio State University, also contributed to the method development. H. B. Bridges many years ago suggested to the author the basic idea for the relative mobility treatment developed herein. He is currently with Shell Oil Company in Denver, Colorado. The author is grateful to these and other persons who contributed to the development of this method. ★ ★ ★



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FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

# NEW PACKER

*at the top*

**HALLIBURTON "SV-DC" SQUEEZE PACKER** is a sliding-valve drillable cast tool. Incorporated into the design of this new drillable tool are proven features of other Halliburton squeeze packers for maximum performance . . . dual slips for better anchoring . . . hard and soft rubbers for maximum sealing . . . *plus the unique, built-in spring loaded, pressure balanced valve to help hold pressure from either direction when closed.* The sliding-valve feature helps prevent loss of mud to formation due to low breakdown pressure, holds annulus fluid load away from weak formation below packer when circulating valve is removed, etc. Available in most popular casing sizes.

# TAILORED CEMENTS

*in the middle*

**HALLIBURTON LOW WATER LOSS CEMENTS** have been developed to help improve squeeze cementing techniques. The ability of these low water loss compositions help to prevent premature dehydration and slurry loss to thieving formations . . . permitting low pressure squeezing without overdisplacing and high pressure squeezing (by the hesitation technique) with filter-cake or node buildup in perforations.

**HALLIBURTON CEMAD-1** is an excellent low temperature, low water loss cement additive for A.P.I. Class A, C, and E Cement and Pozmix Cement.

**DIACEL LWL** is a combination water loss control agent and retarder for Pozmix and various A.P.I. classes of cement . . . can be accelerated for low temperature application.

**HALLIBURTON LA-2 LATEX** is a very unique low water loss additive for cement to produce slurries with improved bonding and better perforating properties.

# NEW BRIDGE PLUG

*at the bottom*

**HALLIBURTON WLC BRIDGE PLUG** is now available in tubing and in some casing sizes. This bridge plug may be wire line set, or, if the tool is run on tubing, it may be set with a modified mechanical circulating valve. The WLC Bridge Plug is designed to hold differential pressures to 10,000 psi.

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# COUNTERBALANCE CAN BE DETERMINED FROM DYNAMIC, UNBALANCED AND FRICTION LOADS

**This new approach involves equations which permit the calculation of the dynamic and pump load. The unbalanced load is determined from static conditions**

J. R. NORTON, P.E., *Oklahoma State University, Stillwater, Oklahoma*

COUNTERBALANCE LOAD or weight requirements in rod pumping can be calculated by the use of a new approach which takes into consideration the dynamic load arising from the motion of the rods and fluid column, the unbalanced static load and the friction load between the fluid and the tubing.

Use is made of the equations developed to predict dynamic loads in rod lines (see *The Petroleum Engineer*, April 1960, pg. B-33, "Dynamic Loads in Sucker Rods"). From these equations, the magnitude of the dynamic load at the polished rod and at the pump may be determined. The real part of the pump load, i.e., the component which is not multiplied by the imaginary operator "i," is the friction load of the fluid column along the tubing surface.

The unbalanced static load can be determined from the magnitude of the static weight of the rods and fluid column. Friction in the pumping unit, stuffing box, between the rods and tubing, and within the pump itself is not considered in this analysis.

In the efficient application of pumping equipment, probably no single factor is more important than arriving at the proper amount of effective counterbalance. In fact, since the dynamic load changes hour by hour due to changing well conditions, it is desirable that the counterbalance change with these conditions.

There are several ways of arriving at the proper counterbalance requirements, all of which depend upon the analysis of instrumentation results. This paper is in no way intended to supplant those methods, but rather to define those quantities which determine the counterbalance requirements. With these quantities defined and their nature known, further instrumentation to automatically control the counterbalance for most efficient operation may be designed. In the absence of weighing instrumentation, application of the following analysis will result in the determination of an approximate counterbalance requirement for a given operating condition.

The pumping operation is a cyclic process, wherein by the nature of the valves the load over each half cycle is different. Efficient utilization of power requires that the work done over each half cycle be as nearly equal as possible. When this condition is realized, excessive power to lift the oil or the counterbalance weights is reduced to a minimum. Under these conditions, the gear box torque is also equalized, and pumping conditions, in general, approach an idealized state more nearly in keeping with the simplifications required in producing an analytical approach.

## How to Determine Counterbalance Needs

The horsepower requirements for either the upstroke or downstroke are given by the following formula as developed in "New Method Predicts Polished Rod Input Power Requirements," page B-56, *The Petroleum Engineer*, September 1960:

$$HP = \frac{(DL + UL + FL)\,NL}{26{,}980} \quad . \quad . \quad . \quad (1)$$

where:

DL is the dynamic load,
UL is the unbalanced static load,
FL is the friction load, and
NL is the product of strokes per minute and stroke length in feet.

Designating these various loads by the subscripts "u" for up and "d" for down, expressions may be written for the horsepower over each one half cycle.

Upstroke Horsepower:

$$HP_u = \frac{(DL_u + UL_u + FL_u)\,NL}{26{,}980} \quad . \quad . \quad . \quad (2)$$

Downstroke Horsepower:

$$HP_d = \frac{(DL_d + UL_d + FL_d)\,NL}{26{,}980} \quad . \quad . \quad . \quad (3)$$

By equating expressions 2 and 3, it is evident that only the loads remain, since the $\frac{NL}{26{,}980}$ factor cancels. These loads are instantaneous loads and must be equalized for efficient power utilization. The resulting expression is then:

$$DL_u + UL_u + FL_u = DL_d + UL_d + FL_d \quad . \quad . \quad (4)$$

The dynamic loads and friction loads may be calculated and are independent of counterbalance except as the amount of counterbalance may cause velocity variations throughout the cycle.

The unbalanced loads on the other hand are directly dependent upon the counterbalance; therefore, it is necessary that $UL_u$ and $UL_d$ be expressed in terms of the counterbalance.

On the upstroke, the unbalanced static load is the difference between the weight of the oil and rods and the counterbalance weight, i.e.,

$$UL_u = W_r + W_o - CB$$

where: CB = theoretical counterbalance required.

On the downstroke, the oil column is inactive and the unbalanced load is:

$$UL_d = CB - W_r,$$

where

$W_r$ = weight of the rods in the fluid,
$W_o$ = weight of fluid on the pump.

Substituting these unbalanced load expressions in Equation 4 results in the following:

$$DL_u + W_r + W_o - CB + FL_u = DL_d + CB - W_r + FL_d \quad . \quad . \quad . \quad . \quad (5)$$

Solving Equation 5 for CB gives an expression for the proper counterbalance:

$$CB = W_r + \frac{W_o}{2} + \frac{1}{2}\left[(DL_u - DL_d) + (FL_u - FL_d)\right] \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

From Equation 6 it is evident that the required counterbalance is dependent upon $W_r + \frac{W_o}{2}$ as is frequently used.

However, it is also evident that depending upon the pumping speed, length of stroke and relative size of system components, additional counterbalancing is required.

**Dynamic and friction loads.** To calculate the dynamic loads and friction loads requires that the upstroke and downstroke pump loads be calculated. In fact, the friction load is given by the **real** part of the pump load formulae. These pump loads are as follows:

Upstroke Pump Load

$$F_{pu} \approx V_p n^2 \left[31 v l \rho + i\omega M_f\right] \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

Downstroke Pump Load

$$F_{pd} \approx \left(\frac{V_p d_p}{2}\right)^2 . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

where

$V_p$ = pump velocity = $\frac{NL}{19 \cos \beta l}$

$n = \frac{\text{net area pump}}{\text{net area tubing}}$

$v$ = kinematic viscosity

$l$ = length of fluid column

$\rho$ = density of fluid

$\omega$ = angular frequency = $\frac{SPM}{9.55}$

$M_f$ = mass of fluid in the tubing = $\frac{W_o}{32.2}$

$d_p$ = diameter of pump in inches.

Having expressions for the pump loads, the dynamic loads on upstroke and downstroke are given by the following relationship for straight rod lines:

$$DL_u = F_{pu} \cos \beta l + iV_p Z \sin \beta l \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

$$DL_d = F_{pd} \cos \beta l + iV_p Z \sin \beta l \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

where

$\beta l = \frac{Nl}{162{,}000}$ radians

Z = rod line impedence, and is given below for various rod sizes:

| Rod Size: | 1-in. diam | ⅞-in. diam | ¾-in. diam | ⅝-in. diam |
|---|---|---|---|---|
| Z: | 1110 | 1110 | 820 | 525 |

i = the complex notation operator indicating 90 degrees rotation of the term multiplied by i, with respect to the real term

It is important to note that the dynamic and friction loads on the downstroke are negative. That is, these loads are the variation from the mean static loads and hence are positive on the upstroke and negative on the downstroke. Either the signs can be observed or, more simply, Equation 6 can be rewritten taking the signs into account, resulting in

$$CB = W_r + \frac{1}{2}\left[W_o + DL_u + DL_d + FL_u + FL_d\right] \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

## Sample Calculation

The following example illustrates the use of Equation 11.

| | |
|---|---|
| Total rod length | = 7600 ft |
| Rod size | = ¾-in. diam (straight) |
| Tubing size | = 2½-in. diam |
| Pump size | = 1½-in. diam |
| Pumping speed | = 7 SPM |
| Length of stroke | = 9 ft |

Assumed specific gravity = 1, and viscosity = $1.2 \times 10^{-5}$.

Mass of fluid in tubing:

$$M_f = \frac{W_o}{32.2} = \frac{1.937 \times 7{,}600}{32.2} = 457$$

Angular frequency $\omega$:

$$\omega = \frac{SPM}{9.55} = \frac{7}{9.55} = = .734$$

Transformation ratio, n:

$$n = \frac{\text{net area pump}}{\text{net area tubing}} = .294$$

$$n^2 = .0864$$

Phase constant:

$$\beta l = \frac{SPM \times \text{length of rods}}{162{,}000} = \frac{7 \times 7600}{162{,}000} = .328 \text{ radians}$$

.328 radians = 18.79 degrees

$\cos \beta l = .947$ $\qquad$ $\sin \beta l = .322$

Pump velocity $V_p$

$$V_p = \frac{NL}{19 \cos \beta l} = \frac{7 \times 9}{19 \times .947} = 3.49 \text{ ft per sec.}$$

Impedance Z of ¾-in. rods = 820

$$F_{pu} = V_p n^2 [31\ vl\rho + i\omega M_t]$$
$$= 3.49 \times .0864\ [31 \times 1.2 \times 10^{-8} \times 7.600 \times 1 + i.734 \times 457]$$
$$= .3015\ [283 + i\ 335]$$
$$= 85.3 + i\ 101$$
$$F_{pd} = \left(\frac{V_p d_p}{2}\right)^2 = \left(\frac{3.49 \times 1.5}{2}\right)^2 = 6.85$$

With the above information the dynamic loads may be calculated as follows:

$$DL_u = [85.3 + i\ 101]\ .947 + i\ 3.49 \times 820 \times .322$$
$$= 80.78 + i(95.6 + 921)$$
$$= 80.78 + i\ 1017 \approx |1018|\ \text{lb}$$
$$DL_d = 6.85 \times .947 + i\ 3.49 \times 820 \times .322$$
$$= 6.49 + i\ 921 \approx |922|\ \text{lb}$$

(Function of the complex notation operator, "i," is demonstrated in the following example:

If $DL_u = 80.76 + i\ 1017$,

$DL_u = \sqrt{(80.76)^2 + (1017)^2} \approx 1018$ in magnitude.

The theoretical counterbalance required as given by Equation 11 is then:

$$CB = 10{,}875 + \frac{1}{2} \times 4370 + 1018 + 922 + 85.3 + 6.85$$
$$= 10{,}875 + 3201 = 14{,}076\ \text{lb}$$

The calculated amount of counterbalance neglects friction in the pumping unit, stuffing box, between the rods and tubing, and within the pump itself. Therefore more counterbalance will be required than is indicated by the theoretical expression. In addition, the amount of counterbalance changes with any change in well conditions. The most variable of all well conditions and the one most frequently changed is pumping speed. Fig. 1 shows how the amount of counterbalance varies with pumping speed.

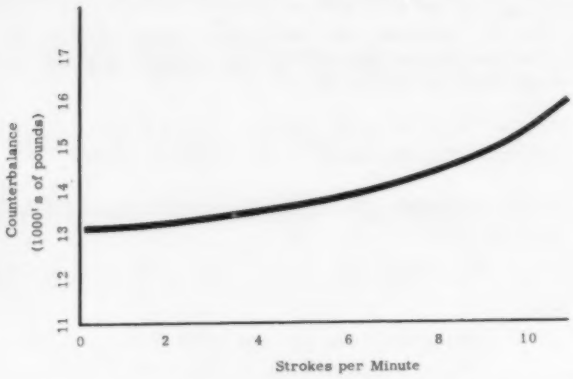



FIG. 1. **Amount of counterbalance** changes with any change in well conditions; and, the most frequently changed variable is that of pumping speed. Here's how counter-balance requirements change with pumping speed.

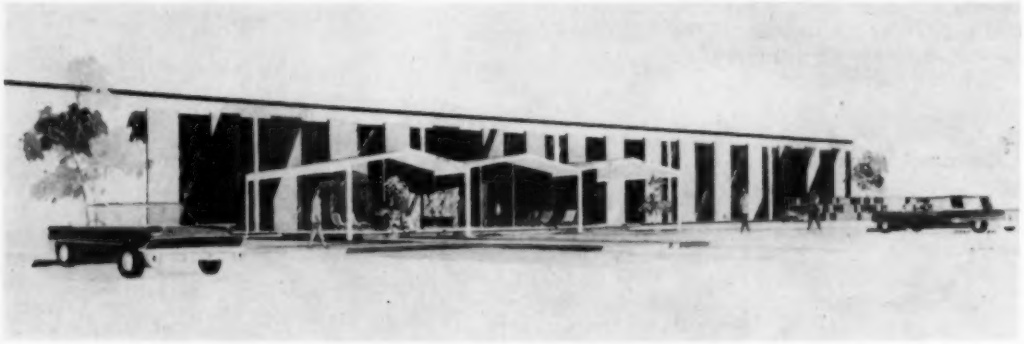

## Acknowledgment

Acknowledgment is made of the sponsorship of W. C. Norris, Manufacturer, Division of Dover Corporation, Tulsa, Oklahoma, without which the original work from which this paper has resulted could not have been accomplished.


## References


1. Norton, J. R., "Dynamic Loads in Sucker Rods," *The Petroleum Engineer*, April 1960.
2. Norton, J.R., "New Method Predicts Polished Rod Input Power Requirements," *The Petroleum Engineer*, September 1960. ★ ★ ★


## *Otis Engineering Breaks Ground For New Office, Manufacturing Plant*



Otis Engineering Corporation, manufacturers of oil well production and safety equipment, formally broke ground last month on a new 68-acre general office and manufacturing facility located on Belt Line Road and Webbs Chapel Road at Carrollton, Texas, near Dallas.

Officiating for Otis were H. C. Otis, Sr., chairman of the board, and Robert H. McLemore, president. Civic dignitaries from surrounding communities and Dallas attended. Construction on office building and manufacturing plant is scheduled to begin immediately.

Architecture will be modern contemporary with buildings arranged in a campus style to suit the topography of the property and surrounding area. New Otis plant will encompass a two-story office, research and engineering building of 80,000 sq ft, a 100,000 sq ft manufacturing plant and an 8000 sq ft fleet maintenance depot which already is in use on the location. Four parking areas to accommodate 450 automobiles will be included, and all buildings will be air conditioned, including the manufacturing plant.

Otis Engineering is a subsidiary of the Halliburton Company of Duncan, Oklahoma.

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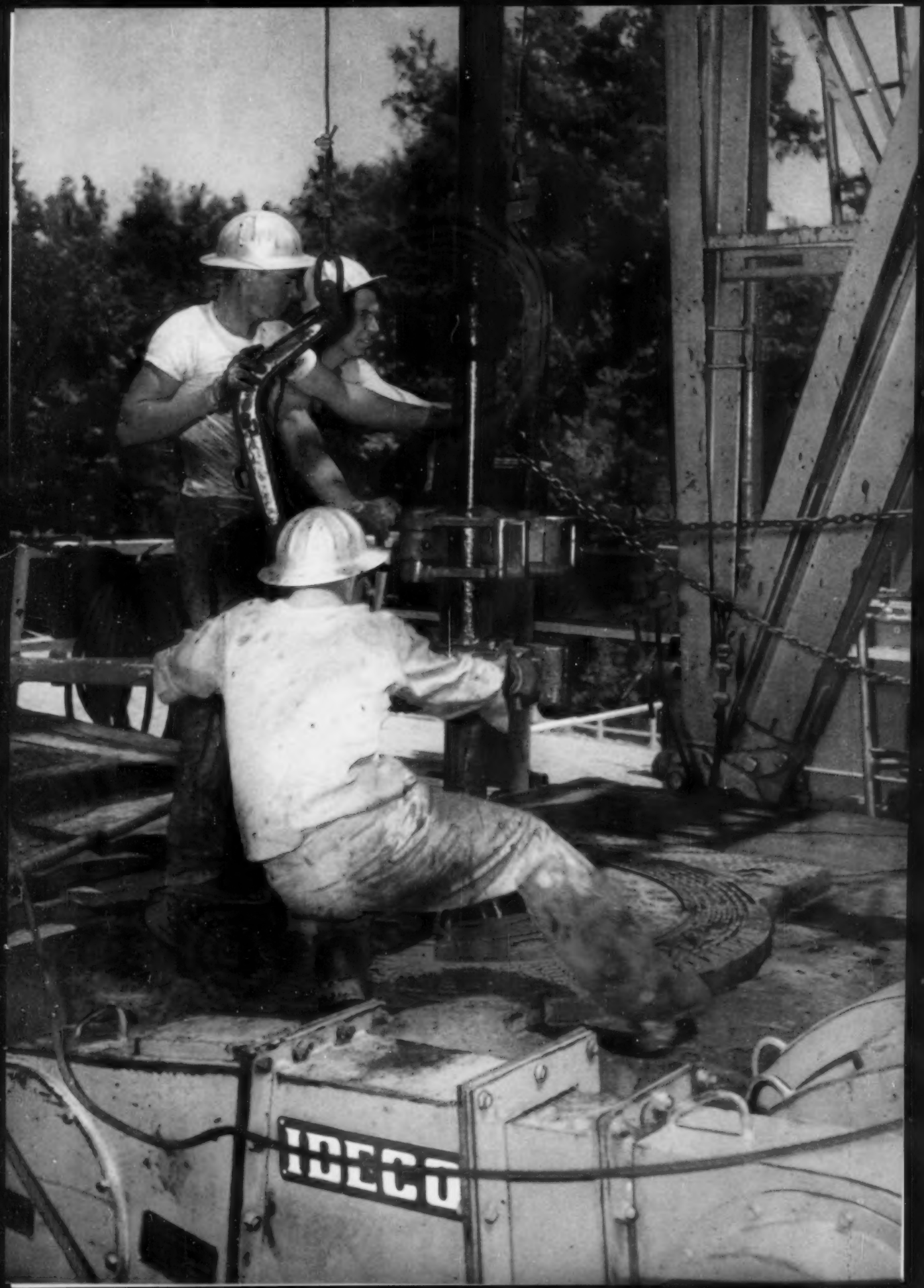
IDECO

# From "Spudding In" to "Bringing In"... J&L Tubular Products Help Cut Running Time

You see a lot of J&L pipe in the oil country. It's specified by top operators who know J&L quality and want to save themselves time and trouble.

*Take Drill Pipe*, for example. Nearly all your deep hole drilling records have been set with J&L drill pipe. You have grades D, E, Blue Ribbon, and Blue Ribbon Vanadium to choose from. Ends are upset and finished to accommodate flash-weld and shrink-type tool joints.

*J&L Grayloc® Tubing* is another example. It's held the highest well pressures anyone's hit so far. The Grayloc joints are sealed tight by an independent ring. And the heavy, square threads take the strain of make-up many times without impairing the seal.

*On severe, variable drilling* operations, J&L Buttress Thread casing gives you joints as strong as the pipe itself. You can put more casing in the hole faster with Buttress Thread casing. You get easier stabbing and rapid spinning, and use fewer power strokes to tighten the coupling.

Look over some rigs where they're using J&L. J&L has invested millions in the finest pipe-making equipment known. J&L has a quality control program as exacting as any in the whole industry. Ask your J&L salesman to prove it . . . he'll be glad to.

**Grayloc®** manufactured under license from Gray Tool Company, Houston, Texas.
***Extreme Line** produced under license from the Material Supply Company.

Steel

## Jones & Laughlin Steel Corporation

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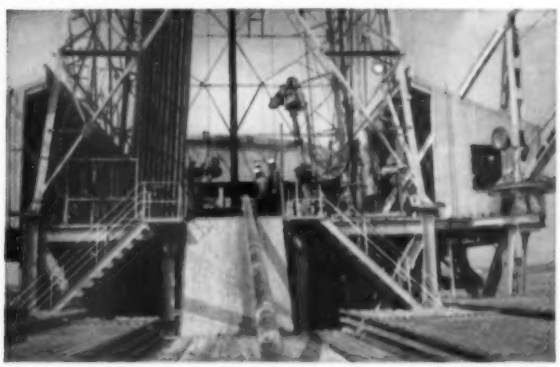
**Sun Oil Company** knows that J&L Grayloc® Tubing provides positive leak resistance at high pressures. J&L Grayloc Tubing can be run again and again. The tubing joint has an independent sealing ring that will hold against the highest well pressures yet encountered.

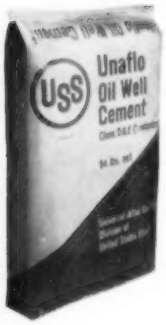
**J&L Extreme Line* casing** provides maximum joint strength and allows up to 50% higher running speeds than for conventional API T&C casing in the same size and range length.



**At Bell Isle Corporation No. 43 well,** southwest of Morgan City, La., Sun Oil used 5,813 feet of J&L Buttress Thread casing in the top sections of the 9⅝" casing. "The high strength of J&L Buttress Thread casing was used so a much longer and heavier intermediate string could be run," the drilling superintendent reported.

J&L

STEEL

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At all depths, UNAFLO oil-well cement provides a slurry that follows the irregularities of well bore and pipe . . . remains fluid under down-the-well temperatures and pressures . . . stays pumpable after a period of rest . . . is easily reversed out . . . yet sets hard to provide an adequate seal. That's because the retarded set of UNAFLO sustains high initial fluidity. This postponement of initial thickening allows ample time for proper placement plus a margin of safety for delays or emergencies.

For cementing or recementing, for plug-backs or squeezes, at varying depths, pressures and drilling conditions, UNAFLO cement provides the workable slurry – one that pumps easily, sets hard. For more data, write Universal Atlas Cement, 100 Park Avenue, New York 17, N. Y.

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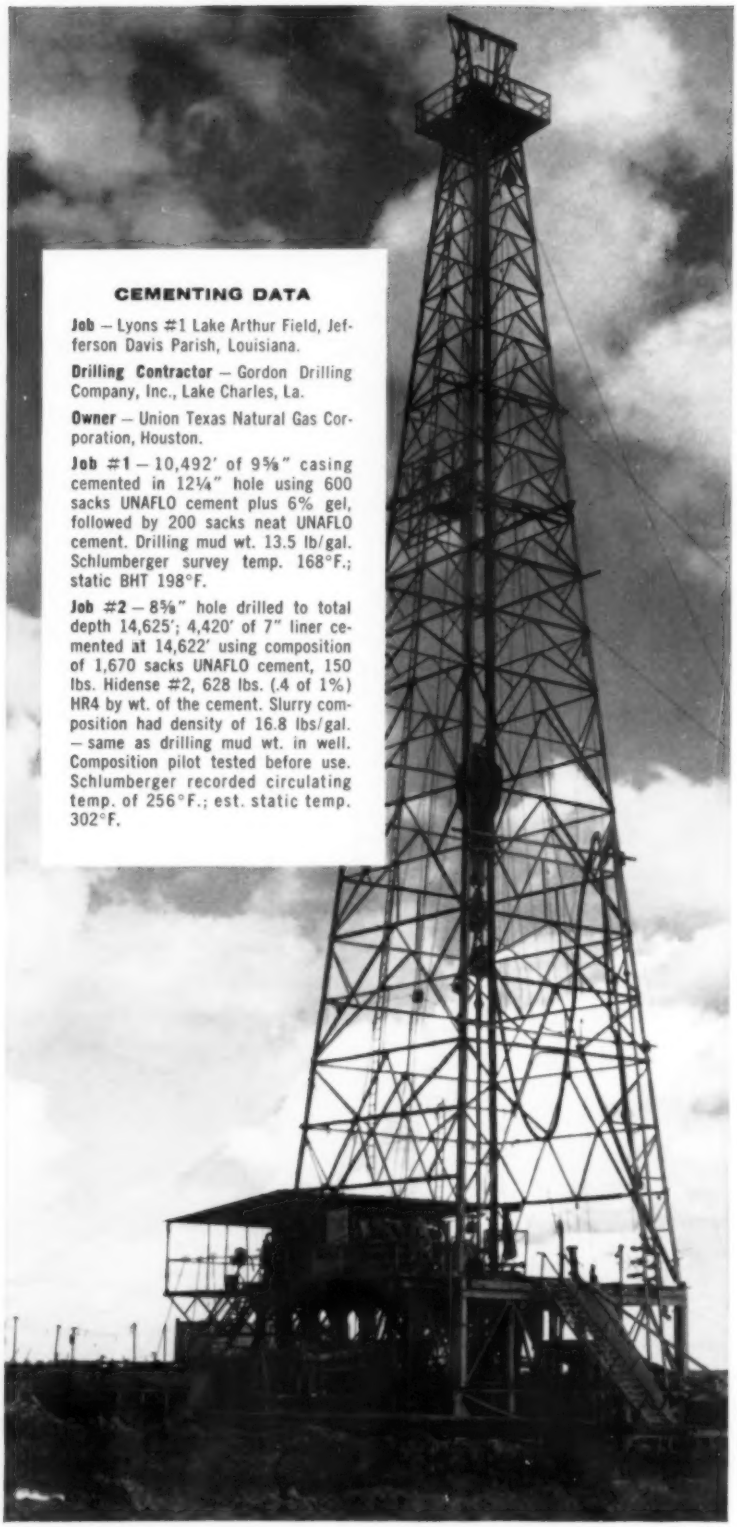

**CEMENTING DATA**

**Job** – Lyons #1 Lake Arthur Field, Jefferson Davis Parish, Louisiana.

**Drilling Contractor** – Gordon Drilling Company, Inc., Lake Charles, La.

**Owner** – Union Texas Natural Gas Corporation, Houston.

**Job #1** – 10,492′ of 9⅝" casing cemented in 12¼" hole using 600 sacks UNAFLO cement plus 6% gel, followed by 200 sacks neat UNAFLO cement. Drilling mud wt. 13.5 lb/gal. Schlumberger survey temp. 168°F.; static BHT 198°F.

**Job #2** – 8⅝" hole drilled to total depth 14,625′; 4,420′ of 7" liner cemented at 14,622′ using composition of 1,670 sacks UNAFLO cement, 150 lbs. Hidense #2, 628 lbs. (.4 of 1%) HR4 by wt. of the cement. Slurry composition had density of 16.8 lbs/gal. – same as drilling mud wt. in well. Composition pilot tested before use. Schlumberger recorded circulating temp. of 256°F.; est. static temp. 302°F.

U-164

**Universal Atlas Cement**
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**New Forging Press Is World's Largest**

The world's largest multiple ram forging press equipped for forging steel, refractory metals, or high density and sophisticated alloys in closed dies has been designed by Cameron Iron Works, Inc., and installed in their Houston plant.

Total load on main down-acting rams is 20,000 tons, and the press is designed to provide forging techniques which allow intricate shapes to be forged in one heat for uniform grain size.

★ ★ ★

**Instrument Detects Internal and External Casing Corrosion**

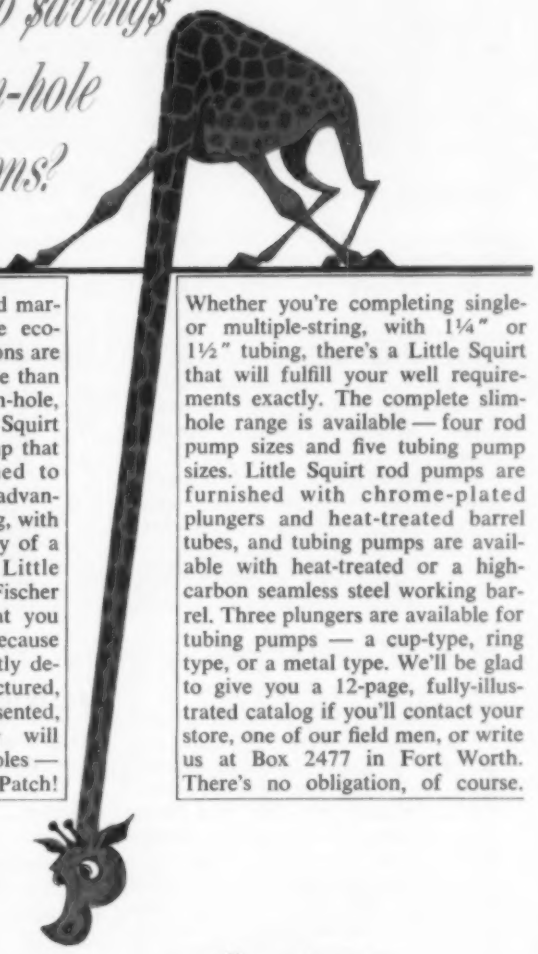
Shell Development Company has unveiled a new instrument designed to detect corrosion on both the inside and outside of oil well casing. The instrument uses an electro-magnetic wave to measure thickness of the casing walls and can spot a thinning 1/200th of an inch deep, according to the designers.

An exciter coil, small enough to be lowered into a well, transmits alternating waves which travel to the casing surrounding it and then back to a pick-up coil beneath the exciter. Time required for a wave to make the trip between the coils is determined by the thickness of the steel through which it passes. Thus, changes in wall thickness are reported in terms of fluctuations of the waves' travel time.

Data are transmitted to instruments on the surface by electronic components which are encased in the hollow, 7-ft tube on which the coils are mounted. A pen recorder on the surface follows the descent of the probe, drawing a profile of the casing's thickness from top to bottom.

**In slim-hole completions,** one of the basic concepts is to equip a well for maximum income at a minimum investment. To acomplish this, the operator must install downwell equipment that will produce the desired allowable, despite its small-scale size. Operators who have been hesitant about slim-hole completions because of a lack of adequate pumping equipment can now get rod or tubing pumps in a full range of slim-hole sizes, with the assurance that the equipment will afford the same efficiency and performance as conventional-sized sub-surface pumps. As a result, the slim-hole trend has steadily increased — for marginal wells, for wells with virtually-depleted pays, and even new wells in proven areas.


*looking into savings on slim-hole completions?*



With domestic allowables and markets as they are today, the economics of slim-hole completions are worth looking into now, more than ever. When you complete slim-hole, equip your well with a Little Squirt and you'll be running a pump that has been carefully designed to afford all of the production advantages of small-diameter tubing, with the stamina and dependability of a regular-sized pump. The Little Squirt is another Harbison-Fischer special-application pump that you can run with confidence, because you can be sure it is efficiently designed and precision manufactured, that it will perform as represented, and that Harbison-Fischer will stand behind it. For slim-holes — it's the Best Pump in the Oil Patch!

Whether you're completing single- or multiple-string, with 1¼" or 1½" tubing, there's a Little Squirt that will fulfill your well requirements exactly. The complete slim-hole range is available — four rod pump sizes and five tubing pump sizes. Little Squirt rod pumps are furnished with chrome-plated plungers and heat-treated barrel tubes, and tubing pumps are available with heat-treated or a high-carbon seamless steel working barrel. Three plungers are available for tubing pumps — a cup-type, ring type, or a metal type. We'll be glad to give you a 12-page, fully-illustrated catalog if you'll contact your store, one of our field men, or write us at Box 2477 in Fort Worth. There's no obligation, of course.

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**LITTLE SQUIRT** SLIM HOLE PUMP

*get slim-hole production advantages with the stamina and dependability of regular-sized sub-surface pumps*

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# EXPLORATION ACTIVITIES

## ALASKA

### Whipstock Wildcat Spudded Under Cook Inlet Waters

A well is being whipstocked from an onshore location in the Cook Inlet basin and will be bottomed under the waters of the inlet.

Standard Oil Company of California has spudded this first test well, which is on acreage held jointly with Richfield Oil Corporation. Wildcat is designated the Falls Creek 1 and it is being drilled as a tight hole.

## ARIZONA

### Extension Well and Wildcat Left Dry and Abandoned

An extension well and a wildcat drilled in Arizona have failed to find production.

Superior Oil Company failed to extend production south of its Carrizo Mountain gas condensate discovery drilled last year in Apache County, Arizona.

The M 23-21 Navajo, drilled jointly with Pan American Petroleum Corporation was abandoned after being taken to a total depth of 5991 ft. Location is in 36-3n-18w about 9 miles south of Ashfork in Yava County.

## ATLANTIC OFFSHORE

### Seismic Survey Completed Off Five Coastal States

First seismic survey of coastal waters adjoining five middle Atlantic states has been completed by Kerr-McGee Oil Industries, Inc. Covered in the study were New York, New Jersey, Maryland, Delaware, and Virginia.

Work was commenced from the port of Atlantic City, New Jersey and later moved to Lewis, Delaware. Survey was conducted in from 20 to 150 ft of water.

## AUSTRALIA

### 6,000,000 Acre Grant In Queensland Taken

Cordillera Mining Company has entered into an agreement to assign its six-million acre oil and gas concession in the State of Queensland, Australia to subsidiaries of Continental Oil Company, The Ohio Oil Company and Amerada Petroleum Corporation. Assignment of the concession is subject to approval of the Queensland Government.

Group will pay a cash consideration for the concession and Cordillera will retain a 25% working interest.

## CALIFORNIA

### Wildcat Well Underway Off Santa Barbara County

Standard Oil Company of California is drilling a wildcat well in the tidelands off Santa Barbara County, California. Well is below 1200 ft on the 2 State 2198.2 in the Orella area off Santa Barbara County. Test is being drilled from a floating drill ship about 2800 ft. offshore.

The wildcat is on Parcel B, one of two state-owned blocks leased by Standard of California and Humble Oil & Refining Company in 1958. The companies reportedly have established production on the other block, Parcel C, which is four miles to the west, but have failed in their efforts to score on Parcel B.

## CANADA

### Berland River Gas Strike Flows 27 MMcfd On Test

Flows of up to 27 MMcfd were recovered at the Berland River-D3 discovery well belonging to Hunt Oil Company. Company drilled into the Viking sand 55 miles due west of Red Deer in the Ferrier district of Alberta. Maximum flow on the well, designated Hunt 6-26-39-8 Ferrier on LSD 6, 28-39-8w5, was estimated to be 36MMcfd on 10 ft of an apparent 27-ft sand.

## FLORIDA

### Exploratory Search Begun On Western Coastal Waters

First exploratory oil and gas search of Gulf of Mexico open waters bordering Florida's West Coast, north of Charlotte Harbor, has been undertaken by The California Company pursuant to terms of a $10,000,000 contract between this Standard of California subsidiary and Coastal Petroleum Company, wholly-owned affiliate of Coastal Caribbean Oils, Inc.

Scheduled to drill to a minimum depth of 10,500 ft, the drilling barge for the California-Coastal No. 2 State Lease 224-A is located eight miles off the shores of Franklin County and due south of Tallahassee.

First test on the 4,500,000 acre lease went to 14,000 ft on a site four miles off La Costa Island in Lee County and encountered only minor oil shows.

## LIBYA

### Field Discovery Well Flows 4440 Bpd at 6600 Ft

Oil field has been discovered by Oasis Oil Company of Libya, Inc. in Concession 59 of Petroleum Zone No. 2, Cyrenaica. Discovery well, A2-59, flowed 35 gravity oil at the rate of 4440 bbl oil per day from a depth of 6600 ft.

Preparation for two confirmation wells has already been started to further evaluate this discovery, which is about 15 miles north of a previous Oasis discovery in this concession.

## LIBYA OFFSHORE

### Seismic Exploration Begun On 6,700,000 Acre Tract

Marine seismic exploration has begun on Atlantic Refining Company's 6,700,000-acre concession in the Gulf of Sirte, offshore from Libya in the Mediterranean Sea.

Atlantic's concession—actually four separate blocks of acreage linked end-to-end — follows the Gulf of Sirte shore line. Shoreline distance from one end of the concession to the other is some 400 miles. Outer limits of the block range from 25 to 50 miles offshore. Water depth ranges from zero to more than 900 ft.

## LOUISIANA

### Jackson Parish Discovery Flows 77,500,000 Cfd Gas

Drillstem tests by Arkansas Louisiana Gas Company of its No. 1 Kavanaugh well in Jackson Parish of North Central Louisiana showed a calculated open flow at the rate of 77,500,000 cfpd of gas with an estimated three to four bbl of distillate per million. Well flowed from a Hosston zone at 7666 to 7676 ft.

Well is about 13 miles southeast of big Calhoun field of Ouachita parish.

Well will be drilled to 10,500 ft to seek additional zones.

## MISSISSIPPI

### Yazoo County Well Yields 451 Bpd at 10,445 Ft

A Humble Oil and Refining Company discovery, No. 1 Eloise Hicks Thomson in 3-9-1w section of Yazoo County, showed for a potential of 451 bpd in a Hosston zone at 10,445 to 10,453 ft.

Two other Hosston zones were indicated, but first zone at 10,160 ft died during test. Another test was scheduled for the other zone at 10,297 to 10,313 ft.

## OKLAHOMA

### Major County Discovery Flows 640 Bpd of Oil

A discovery well in Major County,

Oklahoma was completed by Arkansas Louisiana Gas Company, at the No. 1-A Ott, to flow at the rate of 640 bbl of oil per day on 20/64-in. choke.

Well is located three miles south of South Mena pool, and was a joint venture with Livingston Oil Company of Tulsa.

Perforations were at 7084 to 7092 ft in the upper Manning zone, which was acidized with 15,000 gal of treating fluid. First flow showed casing pressure of 875 lb and tubing pressure of 125 lb. During a five hour shut-in period this increased to 1250 and 550 lb respectively.

## TEXAS

### Southwestern Jack County Discovery Flows 409 Bpd

A discovery well in southwestern Jack County, Texas flowed 409 bbl of oil on a 12/64-in. choke in 24 hours. Bayview Oil Corporation drilled the well, Gilmore A Well No. 2, to a total depth of 4917 ft. Then a 5½-in. casing was set to 4745 ft.

Pay is a Mississippian zone, with the top of the pay section at 4492 ft, estimated at 200 ft above oil-water contact. Well was perforated opposite the interval 4624 to 4640 ft. Gas-oil ratio was 1200 to 1 and tubing pressure was 900 lb.

### Completion in Wood County Flows 636 Bpd From 3 Zones

Triple zone well has been completed by M. B. Rudman and Shell Oil Company in the Quitman field of Wood County in East Texas. All three zones are in the Rodessa Section. Two of the zones tested a total of 636 bbl of oil per day through small chokes, and the third zone is gas distillate.

This is the second triple completion in the area.

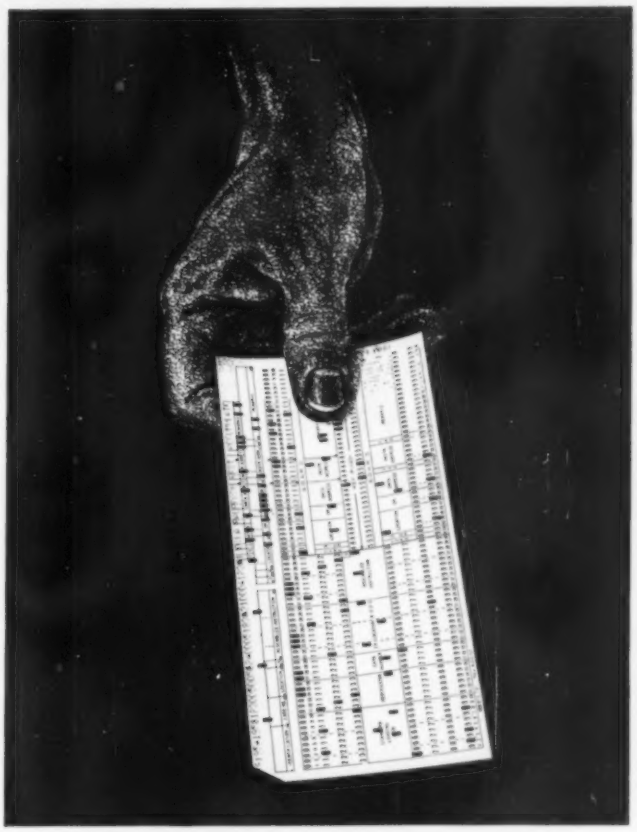
## VENEZUELA

### Lake Maracaibo Oil Well Flows 7800 Bpd On Test

Venezuelan Sun Oil Company has announced the completion of an oil well in Lake Maracaibo which produced 7800 bpd of 30 gravity crude oil through a ¾-in. choke on initial production test.

Drilled on the Block 1 concession held by Venezuelan Sun, Venezuelan Atlantic Refining Company and Texas Seaboard, Inc., the well extends the former productive limits of the field by two-thirds of a mile to the south.

On an initial production test, the well produced 7800 bbl per day of 30 gravity crude oil through a ¾-in. choke.

**this well is misbehaving**

One of the most significant and directly useful "products" of Core Lab's new *CAP* service — COMPUTERIZED ACCOUNTING OF PRODUCTION — is the reporting of abnormal well behavior.

Not only does *CAP* deliver complete, tailormade production summaries (by zones, wells, batteries, leases, fields, and interests) but special reports can be issued when variations occur in well test, production, or injection characteristics. The client specifies the tolerances when his program is designed. *CAP* takes it from there. It's quick and simple, accurate and economical.

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# It's New

## Drilling-Producing Equipment

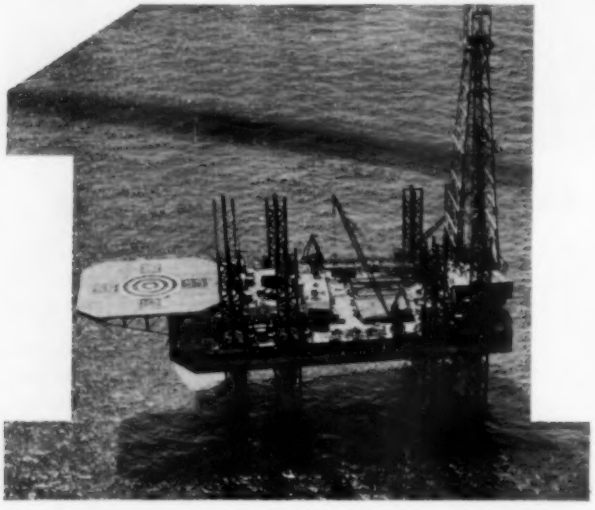
### Fluid Control Valve

Willis Fluid Control Valve was developed for the control of fluid to hydraulically-actuated pumps, including deep well free pumps. A replaceable stem assembly can be installed for highly accurate gas control. The valve incorporates a positive helical orifice that remains the same in cross-sectional orifice areas at all flow volume settings. Regardless of the setting, manufacturer states, there is ample clearance for passage of foreign particles that would normally shut off or clog the annulus of a needle or other type fluid control valve. Three common sizes of interchangeable valve stems with different cross-sectional orifice areas are available to meet various flow control conditions, and they range from 10 to 18000 bpd of fluid with pressure ratings of 1350 psi differential. *Willis Oil Tool Company.*

Circle number (1) on reply card.


**1 OF 6 WAYS TO DRILL OFFSHORE**

The quarter-century of experience OFFSHORE has logged in worldwide operations, an excellent selection of versatile drilling units plus an unexcelled engineering and operations staff, and a record of success in this demanding field enable OFFSHORE to offer you the most economical drilling contract service available *anywhere.*



**SELF-ELEVATING MOBILE PLATFORM**

The most versatile of all, this type of drilling tool operates efficiently in water 15 to 110 feet deep, depending on soil conditions. Repeatedly proved successful under greatly varied weather, water and bottom conditions off the coasts of the U. S., Panama, Trinidad, and in the Persian Gulf. THE OFFSHORE COMPANY now has five units in this category.

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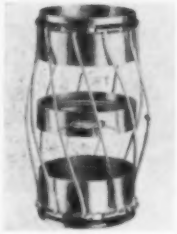
### Improved Insert Valves

Newly-engineered seal on Baker's Insert Float-Check Valve and Insert Flexifill Valve joins valves to their coupling. Installed in casing couplings between pin ends of made-up joints, valves are designed for cementing programs with moderate-depth requirements. Seal is backed-up on top side by body of valve itself, and it is compressed for positive seal-off on its underside by a metal back-ring which is forced upward by pin end of a casing joint. Both seal and back-up ring have matching tapers. Thus seal is prevented from extruding and it can adapt better to varying pin-to-pin distances. *Baker Oil Tools, Inc.*

Circle number (2) on reply card.

### Spiral Centralizer



Spiral-Flo Centralizer has been developed by Weatherford Oil Tool to replace their centri-flo centralizer. Spiral construction diverts or whirls the cement, company says, helping to break up channeling. Field tests have indicated that tool has reduced frictional drag and self-cleaning qualities. New model is designed to run in very close tolerances. *Weatherford Oil Tool.*

Circle number (3) on reply card.

### Fracturing, Cementing Tools

Sand fracturing equipment adapters and setting tools have been added to the Burns Tool line. This includes a screw-down adapter, landing nipple adapter, and setting tool. In cementing equipment, a liner wiper plug made of drillable material has been developed. *Burns Tool Company.*

Circle number (4) on reply card.

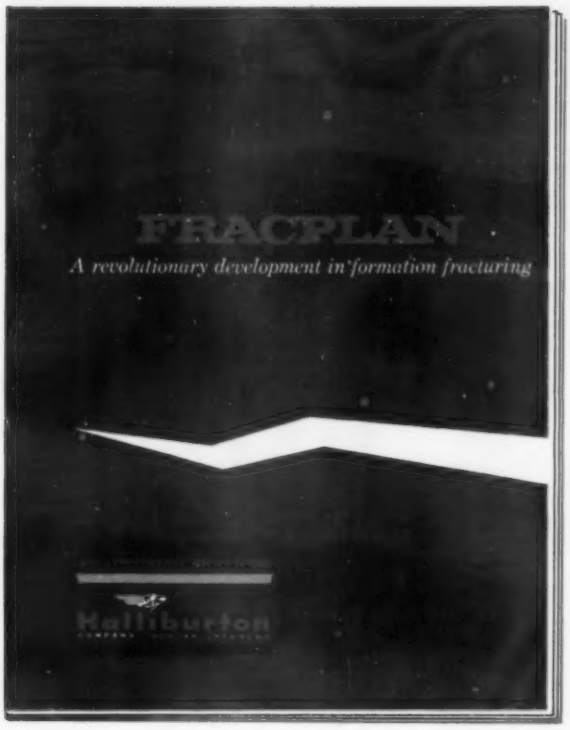
### Rotary Drilling Hose

Rotary drilling hose is constructed with four spirally-wound plies of heavy steel wire so designed to withstand highest pressures encountered in modern drilling. S-B-C line also includes two other grades of rotary hose, a mud suction hose, and a vibrator hose. All are available in a wide variety of standard lengths and sizes to meet every oil field need. *Skinner Bros. Company.*

Circle number (5) on reply card.

### Variable-Speed Belts

A new line of variable-speed belts in a wide range of sizes and types for all industrial applications has been announced by Lovejoy Flexible Coupling. Top widths of standard sizes range from ⅜ in. to 3 in. and have nominal overall lengths from 26.4 in. to 170 in. They feature special

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**THE "PAD VOLUME"** of low fluid loss fluid which precedes the propping particles and fracturing fluid.

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**THE ADDITION RATE** at which the propping agent will be added during injection to permit even distribution of the propping particles throughout the fracture.

Basic descriptions of laboratory procedures, formulae, selection methods, and information needed from the well owner are included in the new FRACPLAN Brochure now being distributed by *your* Halliburton man. Get your copy now from him or write to the Halliburton Company, Duncan, Oklahoma.

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design and construction to withstand the intense squeezing action of pulley sheave walls and provide smooth transmission at full power capacity, manufacturer says. Belts are fabricated from fiber-reinforced synthetic rubber and uniform notching on underside provides flexibility. *Lovejoy Flexible Coupling Company.*

Circle number (6) on reply card.

### Hydraulic Fracturing Tool

A combination tool to prepare a wellbore for hydraulic fracturing by the V-Notch method is available from Grant Oil Tool. Tool is manufactured under license from Gulf Oil Company, which developed the fracturing process. Two types are available, a casing blade and a formation blade. *Grant Oil Tool Company.*

Circle number (7) on reply card.

### Transcribing Seismic Data

Seismic data can be transcribed from paper records onto magnetic tape with Transcorder now being produced by Electrodynamic Instrument. Device will also transcribe recorded data from one size of magnetic tape to another and, with an accessory will transcribe well logging data to magnetic tape for use in seismic data reduction equipment. A reproduction of the seismic trace being transcribed can be produced simultaneously for checking purposes. *Electrodynamic Instrument Corporation.*

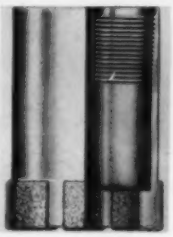
Cicle number (8) on reply card.

### Private Microwave System

A new business microwave product designed to operate in the 12,000 mc frequency band has been introduced by General Electric. New equipment will be added to company's existing 2000 mc and 6000 mc microwave lines, providing complete frequency coverage for business firms planning to make use of new channels allocated by the Federal Communication Commission for privately-owned trunk line systems. Equipment accommodates up to 240 private trunk lines for voice, teletype or data messages. *General Electric Company.*

Circle number (9) on reply card.

### Mill Shoe For Fishing



Designed for milling up stuck fish in conjunction with Globe Junk Basket for recovering loose pieces in the hole, Globaloy Mill Shoe is built for milling a wide variety of junk rapidly.

Mill shoe consists of sintered tungsten carbide particles which are applied to shoes by a special binding process which suspends the carbide particles in an extremely tough and shock-absorbing matrix. An infinite number of sintered cutting particles support all sides of the shoe to provide continuous self-sharpening. When one cutting edge dulls, another takes over until the entire matrix is exhausted. *Globe Oil Tools Company.*

Circle number (10) on reply card.

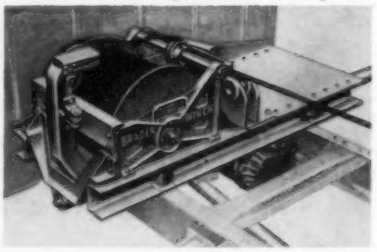
### Ceramic-Coated Plungers

Ceramic-coated pump plungers have been developed for resisting corrosion and wear in waterflood or salt water disposal operation and a wide variety of corrosive fluids. Field Tool and Engineering uses their own formula of ceramic powder which they bond and flame spray on the base metal of the plunger, which is made of stainless steel or corrosion-resistant alloy. While coating is rated as sapphire-hard, company says, it is also very tough and can be dropped on concrete without breaking. Process can also be used to repair worn plungers. *Field Tool & Engineering Company.*

Circle number (11) on reply card.

### Constant Load Winch

Hydraulic winch that combines constant load, constant speed, and constant horsepower has been developed by Braden Winch. Model CL separates power and storage functions of the winch, usually combined in a single drum. Two power



drums pull while a large capacity storage drum takes up the cable. Winch's speed and load remains constant throughout the operation because there is no build-up of layers of cable on the cable drums. An improved level winder protects winch cable and load by winding cable on the storage drum. One man operates two remote control levers, and winch has a 15,000 lb. rating. *Braden Winch.*

Circle number (12) on reply card.

Model KCA Triplex Reciprocating pump, made by the Worthington Corp., Harrison, N. J.

# WISCONSIN-POWERED salt water pump

MODEL VG4D
4-cylinder —
25 to 37 hp

Once started, this Worthington salt water disposal pump becomes an automaton. It works 24 hours a day, every day. To keep up the pace, the pump is powered by a heavy-duty air-cooled Wisconsin Engine that is tailored for the grueling job.

The rugged VG4D Wisconsin is built to stand up under continuous loads. It is precision-fitted to cut wear and upkeep. Its high torque enables the engine to slug through shock loads without stalling.

The air-cooled Wisconsin starts fast and runs smoothly in freezing cold and broiling heat. And you don't have to bother with water or anti-freeze — nor with radiators, water pumps, fan belts, and other water-cooling parts.

For the most power service with the least care, specify Wisconsin Engines on your utility units. Get Bulletin S-249 covering all Wisconsin Engines — 3 to 56 hp.

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Oil Field Distributors for Wisconsin Engines and all types of Utility Units

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### Water System Probe

Unique Oxygen Detector Probe, Model 1060, for use in closed anaerobic water systems in secondary recovery operations or monitoring boiler feed water is available from Crest Instruments. Perfected by Shell Development Company and already widely used in waterfloods, device operates on principle of a differential oxygen cell. In presence of low concentrations of oxygen, exposed strip becomes cathodic. Covered section becomes anodic and preferential corrosion proceeds rapidly underneath Neoprene band. Device operates at temperatures up to 500 F and pressures up to 1000 psi. *Crest Instruments.*

Circle number (13) on reply card.

### 145, 210-hp Diesel Engines

Allis-Chalmers has designed and engineered a 145-hp naturally-aspirated Model 10000 engine and a 210-hp turbocharged 11000 engine. Horsepower ratings of both are at 2200 rpm. Engines have six cylinders with 516 cu in. piston displacement, 4 7/16-in. bore 5 9/16-in. stroke. Turbocharged model operates on as little as 0.366 lb of fuel each bhp hr. *Allis-Chalmers Manufacturing Company.*

Circle number (14) on reply card.

### Directional Drilling Tool

A full gage tool to deflect wells which departs from whipstock methods has been developed and tested by Tangent Engineering. Trudril deflecting and stabilizing tool utilizes weight of the drill string to mechanically expand blade-tipped shoes into the sides of the well bore. These three shoes expand equally in stroke and thrust, but when used as a deflection tool, one shoe is thinner or under gage. They are spaced 120 degrees apart and three ft above the full-gage bit. A weight of 20,000 lb is transferred to the shoes from the drill string, giving over 6500 lb force on each one. A positive clutch between the tool's case and shaft provides orientation on a single point until drill pipe is set down. This disengages the clutch and locks the shoes to the borehole wall, preventing the tool's case from rotating. During drilling the shoes slide down the hole following the bit to guide and stabilize it, which should produce a gradual arc instead of a dog-leg in the hole. *Tangent Engineering Company.*

Circle number (15) on reply card.

**Also mark reply card for free copy of 1960 index of The Petroleum Engineer.**


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announces

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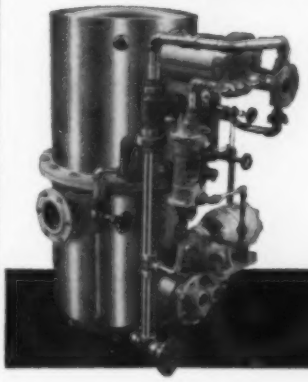

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- SIMPLE TO OPERATE
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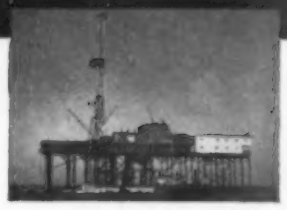

- IDEAL OFFSHORE OR ON LAND
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- 5 MODELS WITH CAPACITIES OF 150 GPD TO 12,500 GPD

This new line of AFM-Maxim Evaporators make fresh water available for large or small drilling operations in any location where any type of raw water, salt or brackish, is available. Using engine jacket water or any other hot water source, Aquavap's operation is fuel free. Units are available for use with engines from 30 HP up. As approximately 5 gallons per day can be produced per unit of horsepower, such a plant could provide 150 GPD of fresh water. Aquavaps are extremely compact. Units, for example, producing as much as 1000 GPD are less than 4 feet high and laterally take only about 2 x 4 feet of floor space. Such a unit would weigh approximately 700 lbs. Other types of AMF-Maxim Evaporators are available with capacities ranging from 150 GPD to more than 1,000,000 gallons per day. For further information write AMF-Maxim Evaporator Division at the address below.

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# New Literature

### Oil Field Equipment

Guiberson has announced a new enlarged catalog for 1961 and 1962 which contains full descriptions, detailed engineering data, complete parts price lists, and numerous illustrations of company's equipment. Exploded parts drawings illustrate the 176 page catalog. *Guiberson Corporation.*

Circle number (16) on reply card.

### Hardfaced Tool Joints

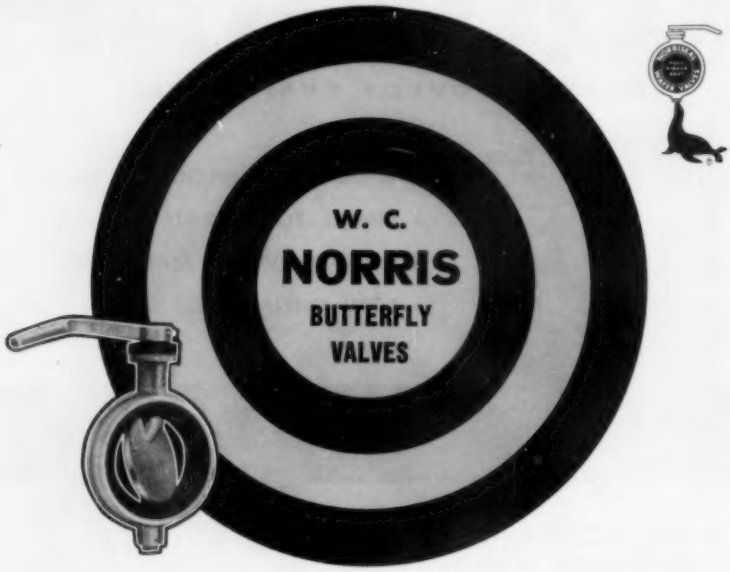
Manufacture and description of hardfaced tool joints is included in a six-page, two-color brochure. Unretouched photographs show distribution of carbide-particles in both high and medium density hardfacing. *The National Supply Company.*

Circle number (17) on reply card.

### High Pressure Motor Valves

A new line of high pressure motor valves containing many unique features are described in a data sheet. For working pressures up to 6000 psi, valves are available in a wide selection of body styles, orifice sizes, trim materials and process connections. *Instruments, Inc.*

Circle number (18) on reply card.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**Versatility-Economy**

Now you can reduce costs and simplify valve specifying by using the highly versatile and economical Norriseal Wafer Type Butterfly Valve. Designed for working pressures to 150 psi, the Norriseal Valve features removable and interchangeable rubber and metal seats . . . takes up less line space . . . can be easily and quickly removed for "on-the-spot" maintenance . . . is field repairable. The wide selection of trim available qualifies the Norriseal Valve for use in many oil field and industrial applications.

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### Steel Pipe

Complete data on corrosion resistance qualities and physical features of Yoloy steel pipe are shown in eight-page, file-size brochure by Youngstown. Available in continuous weld and seamless standard and extra strong pipe sizes, steel is a copper-nickel, high strength, low-alloy steel. *Youngstown Sheet and Tube Company.*

Circle number (19) on reply card.

### Ductile Iron Gate Valves

OIC Valves has released a 12-page brochure covering their new line of gate valves designed specifically for ductile iron. Brochure describes both Pipe-Pal series of ½ in. through 2 in., and Pipe-Mate series of 2 in. through 12 in., large gate valves incorporating a new and stronger "buttressed flange" construction. Complete engineering data on the valves is given plus a description of the properties of ductile iron. *The Ohio Injector Company.*

Circle number (20) on reply card.

### Meters And Accessories

Positive displacement rotary type meters described in illustrated, two-color six-page catalog. Capacities range to 3000 bpd, 5000 lb maximum well pressure, 250 F maximum operating temperatures. Other equipment described includes a sampler electrical impulse transmitter, snap acting pilot, liquid level control valves, metering accessories, sure-flow automatic oiler, gauge glass protector, well testers, and meter prover. *Flow Equipment Company.*

Circle number (21) on reply card.

### Threadless Fittings

A six-page bulletin is now available on Green Triangle Telsco Threadless Fittings. Bulletin features cut-away views of two types of fittings, the 500 and 600, identifying main parts. Photographs of products in use, and data on size, length and approximate weight of various styles of two sizes are included. *Continental-Emsco Company.*

Circle number (22) on reply card.

### Lever Control Valve

A new bulletin issued by American Meter furnishes data on Reliance Type LV-10 lever-actuated control valve for liquid level applications. With a maximum inlet pressure of 400 psi, the valve is equipped for sensitive operation. Details of unit's balanced valve and low-friction rotary seal are clearly shown in cutaway illustrations. Complete dimensions are given in tables and diagrams. *American Meter Company.*

Circle number (23) on reply card.

### Water Hardness Tests

Procedures, reagents and equipment for one-minute water hardness tests are described in a bulletin just issued by Hall Laboratories. Bulletin describes adaptations of Schwarzenback titration method of testing for total hardness, calcium and magnesium. Determinations are both rapid and accurate and are applicable to all waters containing hardness, company states. *Hall Laboratories.*

Circle number (24) on reply card.

# BETTER HYDRAULICS are built into REED FLUSH-FLO JET BITS

***up to 50% more return area***

REED and ONLY REED offers you jet bits with FLUSH-FLO action and these six exclusive features.

1. Additional return circulation area for faster removal of cuttings.
2. Self cleaning action in the bit head as well as over the teeth.
3. Reduced bottom hole pressure that makes jets more effective.
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# new Dowell acidizing aid boosts production–improves success ratios

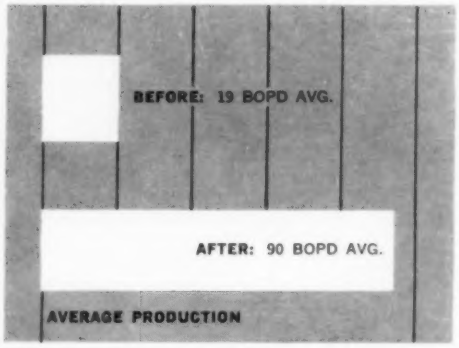
**Slugs of gelled water injected between batches of acid are effective temporary plugs when acidizing long pay sections. Here are results from 21 wells.**

Operators in many areas have found that Dowell water gels provide an economical temporary plug for use in the selective acidizing of long pay sections. These gels contain a breaking agent which causes the gelled water to revert to a thin liquid, primarily by hydrolysis. Breakdown time varies with gel concentration, the presence of acid, and temperature. Overall treatment cost to the operator is often unusually low for the production improvement realized.

As an example, 21 oil wells in the delta area of South Louisiana were acidized using slugs of water gel between stages of acid. Production was from a series of dirty, poorly consolidated Miocene sands interbedded with silt, clay and mudstone. Depths of these wells ranged from 6400 to 11,000 feet. Here is a tabulation of results from all 21 wells:

| WELL NUMBER | LOCATION | PRODUCTION BEFORE TREATMENT, BOPD | PRODUCTION AFTER TREATMENT, BOPD |
|---|---|---|---|
| 1 | WEST DELTA | 8 | 8 |
| 2 | WEST DELTA | 63 | 312 |
| 3 | WEST DELTA | 0 | 17 |
| 4 | WEST DELTA | 41 | 144 |
| 5 | WEST DELTA | 30 | 216 |
| 6 | WEST DELTA | 42 | 140 |
| 7 | WEST DELTA | 0 | 223 |
| 8 | WEST DELTA | 35 | 108 |
| 9 | WEST DELTA | 60 | 203 |
| 10 | WEST DELTA | 0 | 30 |
| 11 | WEST DELTA | 20 | 22 |
| 12 | WEST DELTA | 24 | 24 |
| 13 | WEST DELTA | 7 | 35 |
| 14 | DELTA FARMS | 0 | 0 |
| 15 | DELTA FARMS | 0 | 300 |
| 16 | STELLA | 0 | 20 |
| 17 | GRAND BAY | 0 | 0 |
| 18 | EAST BAY | 22 | 35 |
| 19 | EAST BAY | 17 | 25 |
| 20 | EAST BAY | 3 | 0 |
| 21 | MAIN PASS | 26 | 32 |

Length of perforated intervals treated ranged up to 50 feet. Some treatments used as many as four stages of acid separated by three water gel slugs. Quantities and number of stages were engineered to meet well conditions.




Out of the 21 treatments, 15 showed a definite improvement. The success ratio of 71.5 per cent and the average production increase of 370 per cent were both considered excellent.

As shown above, this water gel, made from water and a Dowell addition agent, is free of solids. It serves well as a temporary plug, yet it thins readily. Viscosity can be tailored to suit well conditions.

When you consider acidizing a long pay section, check with your Dowell representative about water gel slugs. These gels have been used successfully in many areas. Dowell services and products are offered from more than 150 offices and stations in the United States, Canada, Venezuela, Argentina, Germany, France and the Sahara area. Dowell, Tulsa 1, Oklahoma.

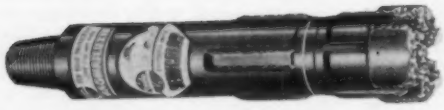
SERVICES FOR THE OIL INDUSTRY

DOWELL

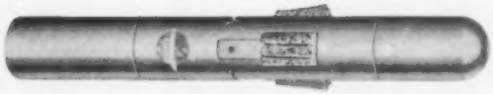
DIVISION OF THE DOW CHEMICAL COMPANY

# SERVCO TOOL GUIDE

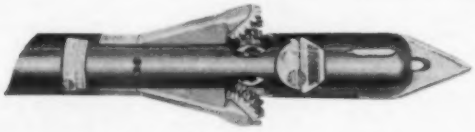
## 8 ways to lower drilling costs



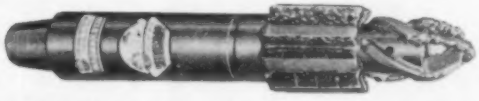
**JUNK MILLS** Tough, rugged tools for chewing up bit cones, packers, drill pipe, junk of all kinds—at rates that make fishing uneconomical.



**SECTION MILLS** Mill any length section at rates up to 4′ per hour. Often complete window cut with one set of arms. Mill all weights of casing from 5″ to 13⅜″ O.D.

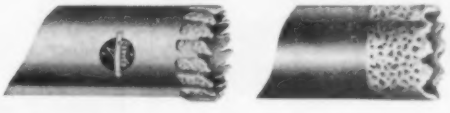


**HOLE OPENERS** *Rock Bit Type:* Opens hole up to twice the bit diameter in hardest formations. Also, *Blade Type* increases hole diameter up to 17″, simultaneously with drilling, in soft to medium formation.



**PILOT MILLS** Mill wash pipe, casing, liner, liner hanger, drill pipe or tubing at rates up to 10′ per hour; drill collars up to 2′ per hour. The perfect tool for swaged casing completions.

**TAPER MILLS** Mill collapsed casing, enlarge holes through adapters or retainers, mill out dented casing, and for general reaming.



**ROTARY SHOES** Difficult washover and milling jobs completed in a fraction of the time required by conventional shoes. Tooth type to cut formation; perforated type to cut iron and formation.

**REAMER-STABILIZERS** Keep hole to gauge in the roughest, sharpest sands. Save rig time and money by eliminating double drilling and separate reaming operations. SERVCOLOY "W" resists wear 5 to 10 times better than conventional hardfacing.

**STABILIZERS** *Welded Blade Type:* rugged, low cost tools with welded wrap-around wings. *Model "B":* Replacement wings quickly changed without removing body from string. SERVCOLOY "W" makes tools last 5 to 10 times longer than conventional hardfacing.

SERVCO tools make downhole milling and drilling safe and economical. The secret of their phenomenal performance lies in the amazing material called *Servcoloy*. Developed by SERVCO and protected by patents, and constantly improved through research and field usage, *Servcoloy* fully utilizes carbide's cutting properties while overcoming its inherent brittleness. Are you profiting from its use? Your SERVCO representative will be glad to tell you how. Call him today.

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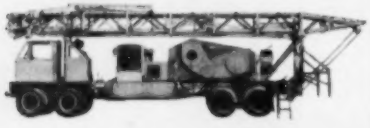
If you're caught in the cost squeeze

Get the facts about WINCHMOBILE JR.

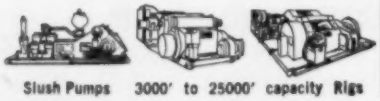


Wilson

Before you buy get the facts on light weight... low cost... long life Winchmobile Junior with the cross mounted engine which saves moving parts and increases hp to the drum by 15%!

WILSON MFG. CO., INC.
Wichita Falls, Texas • The Home of RED IRON

Winchmobiles Traveling Blocks Speedwinches



Slush Pumps 3000' to 25000' capacity Rigs

# RUNNING TOUR with MEN in the INDUSTRY

▸ The California Research Corporation has promoted **Dr. W. T. Holser** from research geologist to senior research mineralogist in the Geology Research Section, in the La Habra Laboratory.

▸ **Bob Altenreid** has joined Chris Well Servicing Company, Ltd. He is a former sales representative for Magcobar in Oklahoma.

▸ Delhi Australian Petroleum Ltd. announced the appointment of **W. J. (Jeff) Greer** as manager of exploration. Greer was with U.S. Smelting, Refining and Mining Company prior to his employment with Delhi-Taylor. He will headquarter in Adelaide, South Australia. **E. Holmes Smart** has joined Delhi as district geologist of the Southeastern region. He was former manager of the Gulf Coast district for Cameron Oil Company in Louisiana.

▸ **F. P. Slingluff** is new sales representative and assistant in special projects for Exploration Service Company. He was formerly with Gulf Oil Corporation.

▸ Gulf Oil Corporation has named **A. C. Godbold** district manager of the Oklahoma City production district, and **H. J. Funkhouser** exploration coordinator for Gulf's domestic production operations at their headquarters in Houston.

▸ **Dr. C. H. Bowman,** a recent Ph.D. graduate of Texas A & M, has joined the production engineering division of Gulf Research & Development Company.

▸ Mobil Oil Company has named **Asa D. McRae** as district exploration superintendent, Midland District, replacing **H. J. Fitzgeorge** who recently transferred to New York.

▸ **Gilbert W. Phillippe** has been named to succeed **Wilbur E. Chalfant** as personnel supervisor of The Ohio Oil Company's Houston Production Division. Chalfant retired after 43 years service with Ohio Oil.

▸ **R. F. "Rufe" Madera,** former chief engineer, Republic Natural Gas Company of Dallas, recently resigned his position to become an independent operator with headquarters in Dallas. He will participate in oil and gas development through drilling and production operations, principally in the Southwest.

▸ Phillips Petroleum Company has made several changes in their international department's exploration and production division:

**D. L. Potter,** appointed Pacific-Asiatic geological coordinator with headquarters in Bartlesville, Oklahoma; **L. M. Richards,** named chief geologist in Venezuela; and **J. W. Henderson,** becomes Spain-Spanish Sahara exploration director for Phillips Oil Company, a wholly owned subsidiary of Phillips Petroleum.

**T. J. Tobin** former drilling engineer with Rutledge Drilling Company of Santa Fe, is now employed by Phillips in Venezuela.

▸ **H. F. Simmons** has been named division exploration manager of Shell Oil Company's Corpus Christi division. He succeeds **J. H. Pittinger** who will assume a special six-month assignment.

▸ Sinclair Oil & Gas Company, has appointed **Stephen A. Dow,** assistant comptroller. Sinclair has also formed a new general staff department to handle utilization and part interest functions with **Lloyd Holsapple,** department manager; **J. H. Rankin,** supervisor of the part interest section; **C. M. Pickrell,** supervisor of the Unitization section.

▸ Appointment of **Edward J. Taafe** as manager, contract and title, Land Department, has been announced by Standard Oil Company of California, Western Operations, Inc. He succeeds **George F. Schroeder,** who retired after 46 years service.

▸ **Paul B. Greig, Jr.,** has been appointed division geologist for Texas Gas Exploration Foreign C.A. The Company recently established offices in the Anglo-American Building in Calgary for the purpose of extending its exploration and production activities into the Canadian area.

▸ British-American Oil Producing Company's new publications director is **Maris G. Fletcher.** He succeeds **Andy Tarvin,** who recently joined the Cain Organization of Dallas.

▸ The Broseco Corporation of Maryland has opened a new oil division office in Fort Worth with **John P. McNaughton,** vice president, as manager. The company hopes to be active as an independent operator representing the interests of the Donaldson Brown family.

▸ **O. A. Fredriksson** has been named supervising research engineer in geophysics development in the La Habra Laboratory of the California Research Corporation.

▸ **Roger M. Dungan** is the new division geologist for Continental Oil Company's Los Angeles exploration division.

▸ **Thomas F. Taylor,** vice president and chief geologist of Grace Oil Company, Houston, has resigned and opened a private office.

▸ Gulf Research & Development Company has announced the appointment of **Dr. T. J. O'Donnell** as associate director of research in Harmarville, Pennsylvania.

▸ **Hamilton M. Ross** has been elected a vice president of Hewitt-Robins Inc. with responsibility for the company's contract engineering operations in this country and abroad. He will be assisted by **Norman M. Godfrey,** who has been manager of the company's eastern sales region.

▸ **Robert L. Reed,** president and director of Wilshire Oil Company of Texas, was elected a director of the Independent Petroleum Association of America.

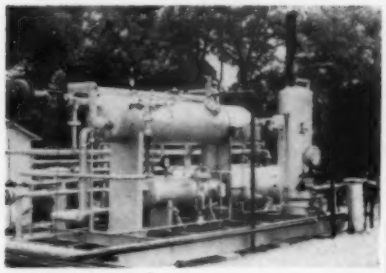
▸ **Jack C. Stipe** was appointed district geologist in charge of exploration in the southern division of Kerr-McGee Oil Industries, Inc. **H. Walton Musick** is the new director of purchases for the company. And in Pittsburgh, a new exploration office has been opened by Kerr-McGee to direct exploration activities for oil and gas in the Appalachian Basin. **Joseph P. D. Hull, Jr.,** will direct the office as district geologist.

▸ **Arthur S. Dickinson,** district geologist for Lion Oil Company a Division of Monsanto Chemical Company, has been named an "exploration geologist" under Lion's new advancement plan for rewarding geologists and geophysicists who find oil for the company.

▸ **A. J. Organ** was appointed vice president and general manager of the Llano Columbia Corporation in Bogota, Colombia. Llano Colombia is a wholly owned subsidiary of Llano Drilling Company of Midland, Texas.

▸ **Richard G. Fagin** has joined the firm of D. R. McCord and Associates, Inc., petroleum consultants. He was formerly associated with Humble Oil and Refining Company in New Orleans as reservoir engineer.

# YOU'RE the winner because M-C has mastered COLD SEPARATION



► Horizontal

▲ Vertical

► Spherical

Your gas dollars can be increased because Maloney-Crawford has combined its engineering know-how and long experience to solve all of the complexities of cold separation. M-C can furnish a cold separation system you can depend on, in any size or shape . . . horizontal, vertical or spherical. With any M-C unit you are assured of the highest distillate recovery and contract dry gas, plus unmatched reliability. If you need cold separation, M-C engineers have the answer. Contact them!

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**TANK & MANUFACTURING CO.**
P. O. Box 659 Tulsa, Okla.


▸ **A. R. McLerran and Associates — Consulting Engineers,** have opened an office in Beaumont, Texas, offering mechanical, structural and electrical engineering services. McLerran is former chief engineer in charge of research development with Ideco, a division of Dresser Industries, in Beaumont.

▸ Two long-time employees of Mobil Oil Company have retired. **Isaac A. Ault** and **Fred E. Joekel** leave Mobil after 39 and 34 years service, respectively. **Edward P. Keeler** has been promoted to staff proration engineer for the Houston exploration and producing division.

▸ At Pan American Petroleum Corporation, **John C. Johnston** has been elected vice president and director, and will serve as manager of the Texas Louisiana Gulf Coast division in Houston. He succeeds **L. Chase Ritts Jr.,** who has been named coordinator — crude oil production, purchasing, and transportation for Standard Oil Company. **William T. Smith** is the new exploration superintendent for the North Texas-New Mexico division, succeeding **William J. Nolte,** who retired after more than 30 years service. **Benjamin F. Baldwin** has been named geologist for the North Texas-New Mexico Division.

▸ Petroleum Technologists, Inc. of Dallas, announced two key promotions: **Charles R. Betzel,** manager of Laboratories; **Vincent Thomas,** manager of sales.

▸ The Research Society at the **Pure Oil Company's** Research Center in Crystal Lake, Illinois, has been installed as a chartered branch of Scientific Research Society of America.

▸ **J. A. Champion** was named area geologist for Shell Oil Company in Houston; while in Midland, **E. N. Van Duzee** retired as production manager after 34 years service, and was succeeded by **W. E. Harpst. John F. Redmond** has accepted the position of vice president in charge of exploration and production with Shell Oil Company of Canada, Ltd. He will be succeeded by **E. G. Christianson. Fremont Roosevelt Schmieder** assumes the post of San Joaquin division production manager in Bakersfield, California.

▸ **Fred Poettman** of Ohio Oil Research is the new chairman of the Denver section of the **Society of Petroleum Engineers of AIME.**

▸ Standard Oil Company (Indiana) has appointed **Eugene W. Kane,** supervisor of the projects analysis division in the crude oil planning department.

▸ **Fred E. Buchanan** became executive assistant to the manager of the Gulf Coast production division of Sun Oil Company.

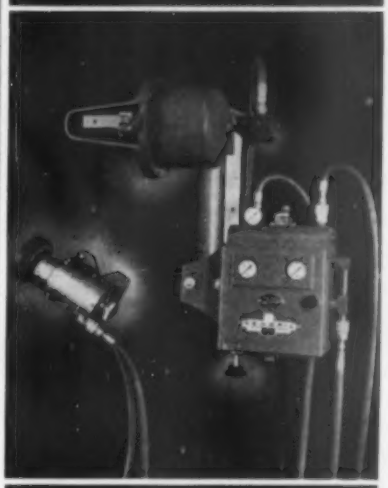
▸ **John N. Troxell,** general manager of the Houston domestic production department of Texaco, Inc., retired January 1 after 38 years service. **Homer O. Woodruff** has been named to succeed him.

▸ Union Oil Company of California announces the appointment of **Ray A. Burke** as director of exploration for the West Texas Division; **Arch Dawson,** director of production, Oklahoma division; and **C. F. Bowden** as manager of the new central division.

▸ **J. W. W. Whitney Jr.,** recently resigned from Helmerich & Payne, Inc., to form the Whitney Operating Company in Tulsa. The new company will specialize in operating and managing oil producing properties including unitized and secondary recovery properties.

▸ Wilson Exploration Company of Fort Worth announced the election of **Byron L. Keil** as vice president, and **Hugh B. Downing,** secretary and treasurer.


# The NEW GEODRIL® AUTOMATIC DRILLER



**gives you**

1. **LONGER BIT LIFE**
2. **FEWER TRIPS**
3. **STRAIGHTER HOLE**

The GEODRIL Automatic Drilling Control was developed, tested and proved in the field by The Geolograph Company, manufacturers of the internationally accepted Geolograph Mechanical Well Logging Recorder.

The new, automatic GEODRIL control has many outstanding features and offers the drilling contractor dependability, economy and safety.

Service for the GEODRIL Control is provided by the experienced personnel of Geolograph Oil Field Services. Their reputation for service is backed by over a fifth-of-a-century of experience in the oil fields.

When you drill your next well, specify the NEW GEODRIL Automatic Driller for maximum drilling efficiency. For additional information, contact your nearby Geolograph Oil Field Services office.

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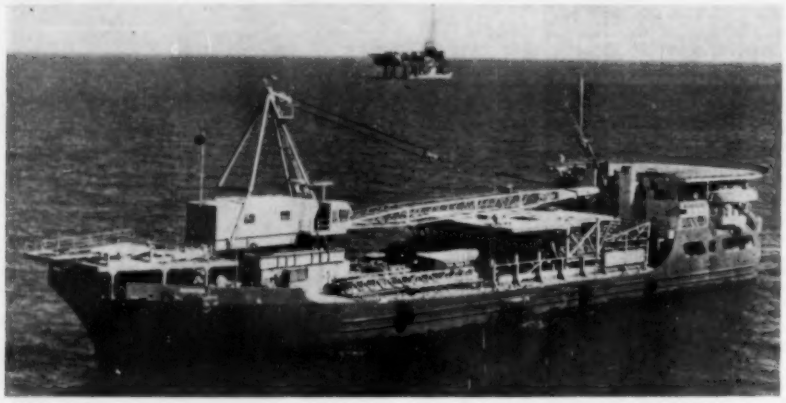
# What's doing in DRILLING

## Dual-purpose Power Plant Runs Tender, Drills Wells



— photo courtesy General Electric Company.

An offshore drilling tender, powered by a dual-purpose diesel-electric plant which propels the vessel while moving and the drawworks while drilling, is now being used by Iran Pan American Oil Company in its Persian Gulf drilling operations. Vessel recently completed a trip halfway around the world from Texas.

Nine-knot Panintoil No. 1 vessel took slightly less than two months to travel the 10,500 miles from the Gulf of Mexico, across the Atlantic Ocean, Mediterranean Sea, and Red Sea to the Indian Ocean and finally to the Persian Gulf.

Trip considerably reduced the normal time which would have been required to tow a drilling barge the same distance.

Unique power plant drives the vessel's propulsion shafts when the ship is underway, and when on location the generators are switched electrically to provide power for the drilling operations.

Vessel is supplied by three service vessels and two helicopters based at Khosrowabad.

Panintoil No. 1 is equipped with a 20,000-ft capacity drilling rig and is drilling an exploratory well in a 6177-sq-mile agreement area. Ship is working in 142 ft of water, 22 miles from the nearest shore.

Drawworks, one of the largest built, is driven by two of these motors. Catworks and 27½-in. rotary table are powered by a third drilling motor. Two 1000-hp mud pumps are each driven by two drilling motors. Other equipment includes two mud mixing pumps, agitators, and conveyors.

A distinctive feature of the craft is the 60-ton crane located forward on the main deck to enable the tender to assemble and dismantle a drilling platform without the aid of a derrick barge. The crane also handles all drilling supplies.

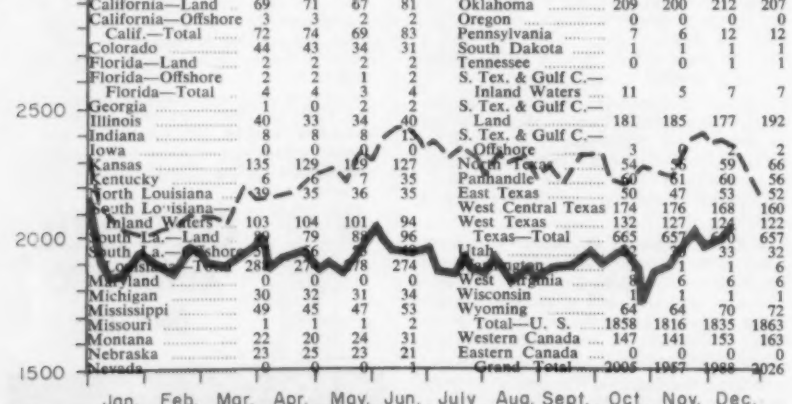
All-welded steel tender hull is 272 ft long with a beam of 56 ft and a loaded draft of 17 ft.

## Rotary Rigs Operating in Oil Fields of United States and Canada

As reported to American Association of Oil Well Drilling Contractors by Hughes Tool Company.

| | Nov. 21 | Nov. 28 | Dec. 5 | Dec. 12 |
|---|---|---|---|---|
| Alabama | 3 | 5 | 6 | 6 |
| Alaska | 8 | 8 | 8 | 4 |
| Arkansas | 12 | 10 | 10 | 9 |
| Arizona | 2 | 1 | 1 | 1 |
| California—Land | 69 | 71 | 67 | 81 |
| California—Offshore | 3 | 3 | 2 | 2 |
| Calif.—Total | 72 | 74 | 69 | 83 |
| Colorado | 44 | 43 | 34 | 31 |
| Florida—Land | 2 | 2 | 2 | 2 |
| Florida—Offshore | 2 | 2 | 1 | 2 |
| Florida—Total | 4 | 4 | 3 | 4 |
| Georgia | 1 | 0 | 2 | 2 |
| Illinois | 40 | 33 | 34 | 40 |
| Indiana | 8 | 8 | 8 | 11 |
| Iowa | 0 | 0 | 0 | 0 |
| Kansas | 135 | 129 | 109 | 127 |
| Kentucky | 6 | 6 | 7 | 35 |
| North Louisiana | 39 | 35 | 36 | 35 |
| South Louisiana— | | | | |
| Inland Waters | 103 | 104 | 101 | 94 |
| South La.—Land | 80 | 79 | 81 | 96 |
| South La.—Offshore | 26 | 26 | 28 | 46 |
| [illegible]—Total | 28 | 27 | 78 | 274 |
| Maryland | 0 | 0 | 0 | 0 |
| Michigan | 30 | 32 | 31 | 34 |
| Mississippi | 49 | 45 | 47 | 53 |
| Missouri | 1 | 1 | 1 | 2 |
| Montana | 22 | 20 | 24 | 31 |
| Nebraska | 23 | 25 | 23 | 21 |
| Nevada | 0 | 0 | 0 | 1 |

| | Nov. 21 | Nov. 28 | Dec. 5 | Dec. 12 |
|---|---|---|---|---|
| New Mexico | 106 | 114 | 116 | 112 |
| New York | 2 | 2 | 2 | 2 |
| North Dakota | 9 | 11 | 10 | 15 |
| Ohio | 5 | 5 | 5 | 6 |
| Oklahoma | 209 | 200 | 212 | 207 |
| Oregon | 0 | 0 | 0 | 0 |
| Pennsylvania | 7 | 6 | 12 | 12 |
| South Dakota | 1 | 1 | 1 | 1 |
| Tennessee | 0 | 0 | 1 | 1 |
| S. Tex. & Gulf C.— Inland Waters | 11 | 5 | 7 | 7 |
| S. Tex. & Gulf C.— Land | 181 | 185 | 177 | 192 |
| S. Tex. & Gulf C.— Offshore | 3 | 0 | 2 | 2 |
| North Texas | 54 | 56 | 59 | 66 |
| Panhandle | 60 | 61 | 60 | 56 |
| East Texas | 50 | 47 | 53 | 52 |
| West Central Texas | 174 | 176 | 168 | 160 |
| West Texas | 132 | 127 | 124 | 122 |
| Texas—Total | 665 | 657 | 660 | 657 |
| Utah | 28 | 29 | 33 | 32 |
| [illegible] | 1 | 1 | 1 | 6 |
| West Virginia | 8 | 6 | 6 | 6 |
| Wisconsin | 1 | 1 | 1 | 1 |
| Wyoming | 64 | 64 | 70 | 72 |
| Total—U. S. | 1858 | 1816 | 1835 | 1863 |
| Western Canada | 147 | 141 | 153 | 163 |
| Eastern Canada | 0 | 0 | 0 | 0 |
| Grand Total | 2005 | 1957 | 1988 | 2026 |




## Drilling Company Receives Department of Army Award

Two citations were presented to Core Drilling, Inc. of Denver, Colorado for record-setting performance in applying oil well drilling practices in construction of an intercontinental ballistics missile base.

Award was presented by the U. S. Department of the Army to Gordon Jackson, president of Core Drilling, for completing the contract work 53 days ahead of schedule. Referring to techniques used, Jackson said that air and foam drilling enabled them to drill with speed and accuracy through the basalts and other extremely hard rocks in the Mountain Home, Idaho area where the base is located.

## Drilling Firm Opens Office For West Texas-New Mexico

FWA Drilling Company of Wichita Falls, Texas has established an operating base in Midland, Texas. Drilling in West Texas and New Mexico will be supervised from the office, with 12 to 18 rigs operating in the area.

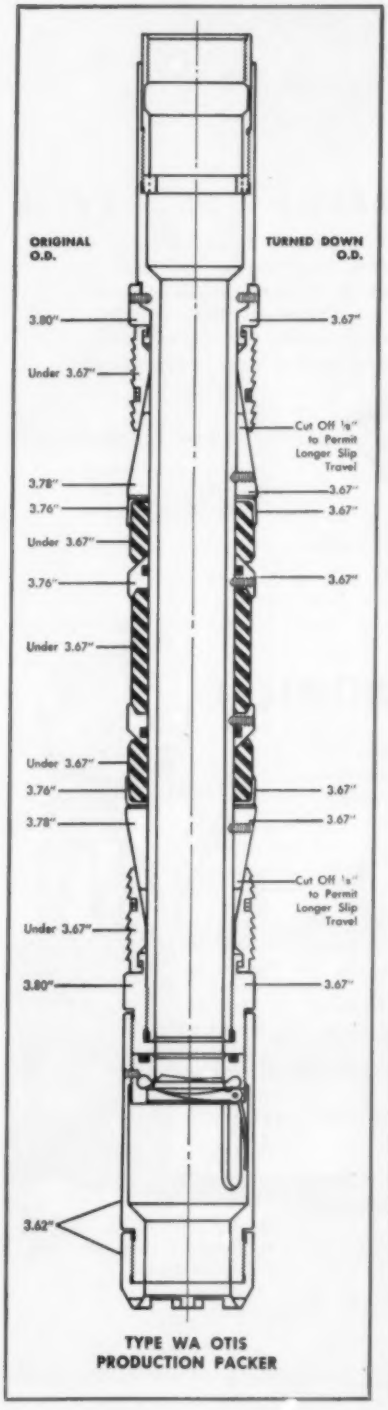
Ernest Cox, who recently moved to the new office from Wichita Falls, will be office manager, and Clint Hurt, contract representative from Midland are in charge.

J. A. Hurt of Odessa is vice president and manager of FWA's operations in this region. Jerrel Langford, also of Odessa, is drilling superintendent.

J. D. Huffaker, president and Harry Campsey, secretary-treasurer, will remain in Wichita Falls.

# OTIS PRODUCTION NEWS

*Volume I, Number 3* **Otis Engineering Corporation • Dallas** *Production Equipment and Services*




TYPE WA OTIS PRODUCTION PACKER

# Two Standard Model 4½" Otis Production Packers Turned Down To 3.67" O.D. And Set in 5" Drill Pipe

HOUMA, LA. – Otis packer specialists from the Belle Chasse and Houma divisions recently solved an extremely difficult well completion problem for one of the major producing companies in their area, by turning down and setting two of their standard model 4½-inch Type WA Production Packers between tool joints in stuck 5-inch drill pipe. The fact that these packers could be turned down from their normal 3.80-inches to 3.67-inches and set in 4.30-inch I.D. pipe, saved the operator a considerable amount of rig time in addition to the cost of having special packers designed and built.

Well conditions at the time the Otis specialists were called in were as follows: 12,500 feet of 5-inch, 19.50-pound drill pipe had become stuck in a salt water flow during final drilling operations and could not be freed. As a result, the pipe had been cemented in place at that depth and cut off at 2900 feet, then tied back to the surface with 7-inch, 29-pound casing. The only potential producing interval was located at 11,600 feet. Before attempting to bring in the well, the operator wanted to plug below, and set a packer above, the potential zone.

Probably the most serious problem facing the Otis specialists on this particular job was the fact that the operator wanted the packers set in the pipe between tool joints. This meant any packer run into the well would have to have an outside dimension of less than 3.75-inches to pass through the tool joints, yet have a sufficient range to set and hold in the 4.30-inch I.D. pipe. Although none of the standard production packers or bridge plugs available today are designed to cover this range, the Otis specialists felt confident their packer could be turned down and run. In the interest of time and cost, the operator agreed to try it.

After first running a 3.68-inch O.D. junk basket to 11,800 feet, the first Otis packer, equipped with an expendable sealing unit, was run in to 11,744 feet and set. In that this packer was to serve as the bridge plug, it was set 4 feet below a tool joint so that the cement to follow would straddle the joint and give a stronger plug. Running time was approximately 5¾ hours, due to the viscosity and weight of the drilling mud. Once set, three dump bailer loads of cement were placed on top of the packer and allowed to set for 12 hours. At the end of that time, the plug was tested to 3500 p.s.i. Where fluid had been lost through the bit prior to plugging, there was no bleed down of pressure.

Next, the drill pipe was perforated and squeezed below and above the intended producing interval and the zone itself perforated. With these operations completed, another turned-down Type WA Packer was run and set between tool joints at 11,570-feet. A successful test to 1500 p.s.i. convinced the operator the packer would hold and swabbing operations to bring in the well were begun.

The help given this operator by his local Otis packer and completion specialists is typical of the service available from all Otis field personnel. Their knowledge of production problems and of the application, installation, and capacity of their equipment permits them to make sound, on-the-spot recommendations. The next time you find it necessary to consult with someone regarding packers or well completion techniques, call the Otis office nearest you or write Otis, Department 3-P, Box 35206, Dallas 35, Texas. You'll find experienced Otis well completion specialists ready to help you – anxious to serve you. © *1960 O. E. C.*

OTIS
Engineering Corporation
General Offices:
6812 Denton Drive • Dallas, Texas



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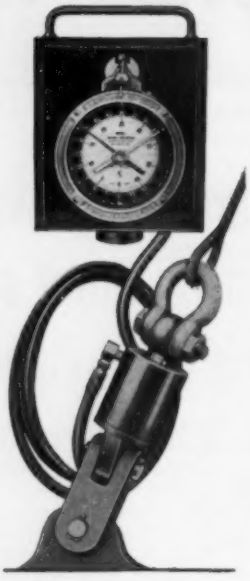
# MIDGET WEIGHT INDICATORS

## A New Concept In Weight Indication for the Well Servicing Unit



Where no deadline anchor is required, the MIDGET anchors the line with a heavy-duty, extremely rugged hydraulic cylinder and piston. The signal developed is transmitted to the gauge maintained near the hoist operator.

The gauge is a 6" fluid filled instrument of the highest quality with a damper for adjusting the pointer movement to the proper sensitivity. The fluid filled case also reduces severe pointer movement and lubricates and protects the working parts.

Two pointers are provided, one reads the total hook load in pounds for two or four lines strung, and the other is a target pointer.

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*Manufacturer*
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# SUPPLIERS' PARADE

## New Companies, Subsidiaries, & Agents

**Armco Steel Corporation** announced that two of its wholly owned subsidiaries, National Supply Company and Union Wire Rope Corporation, were merged with Armco on December 31. National Supply will be operated as the National Supply Division of Armco. Union Wire Rope will also act as a separate unit.

**Continental-Emsco Company** has been named exclusive distributor for Fibercast Company in the Texas Gulf Coast region. Both companies are divisions of The Youngstown Sheet and Tube Company.

W. A. Stoeltzing, Inc., Pittsburgh, Pennsylvania, will serve as sales representative in the Eastern U. S. A. for the **Oil Center Tool Company.**

Establishment of the **Frank Wheatley Pump & Valve Mfr. de Mexico,** was announced by the Tulsa office. The manufacturing outlet is currently manufacturing check valves, non-lubricated plug-check valves and numerous pump parts. S. B. Schoelman is sales manager, Ted Kraft, manufacturing manager.

## Appointments and Promotions

Atlas Bradford Company — **C. E. Macdonald,** manager, export department, formerly vice president of Worldwide Supply Company, Inc.

Black, Sivalls & Bryson, Inc. — **Paul Bartley,** sales vice president.

Borg-Warner Corporation — **William B. Shimer,** director of manufacturing services, formerly with the Chrysler Corporation.

Bucyrus-Erie Company — **Eugene P. Berg,** vice president, and **Ernest S. Everitt,** managing director of Ruston-Bucyrus Ltd. an affiliate company in Lincoln, England, elected to Board of Directors.

Clark Bros. Company, division of Dresser Industries, Inc. — **A. J. Foster,** parts salesman and service supervisor for the Dallas-Midland area.

Continental-Emsco Company — **C. L. Vickers,** vice president, Finance; **Will D. Crowell,** treasurer and credit manager; **Herbert P. Dawkins,** assistant treasurer-credit manager; **John F. Wagenhauser,** general counsel.

SIE Division, Dresser Electronics — **Roy F. Bennett,** assistant to the president.


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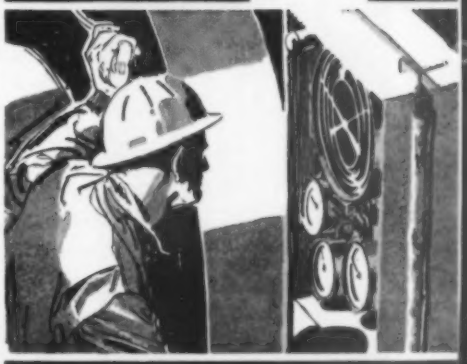

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Your savings from tubingless completions are protected by using the GT-API Modified Coupling with Teflon† seal rings. Leaks are eliminated. And, with no leaks at connections, you know that you're not faced with the possibility of an expensive squeeze job.
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*Also Conventional Completions
†Du Pont's Tetrafluoroethylene Resin


Grove Valve and Regulator Company — **Harold Wolpman,** senior vice president; **Walter L. Connolly,** vice president-manufacturing.

Halliburton Company — **D. R. Yager,** retired as central region vice president, replaced by **E. L. Paramore.**

HOMCO — new sales personnel: **A. F. Criger,** Casper, Wyoming, to handle the rental division; **Jack C. Lattimore,** Tulsa; **Rowland D. Young,** Denver; **Richard D. Arnold,** New Orleans.

Jones & Laughlin Supply Division — **A. B. Colt,** store manager, Carmi, Illinois; **C. T. Owen,** division controller, Tulsa; **C. W. Moore,** district sales manager at Bartlesville, and **J. L. Purser,** salesman at Perry, Oklahoma, have retired.

Johnston Testers, Inc. — **G. D. Duke,** service manager.

Lucey Products Corporation — **John A. Daugherty,** vice president, formerly director of Mid-Continent Supply Company.

McMurry Oil Tool Specialties, Inc. — **B. F. "Fritz" Krause,** special representative, formerly with Garrett Oil Tools.

Schlumberger Well Surveying Corporation — **F. G. Williams,** sales engineer, Liberal, Kansas; **J. V. Crues,** Location manager, McCamey, Texas; **C. F. Grice,** operations engineer, Houston; **D. M. Quillin,** assistant to the area manager, Mid-Continent area; **E. S. Scholl,** division engineer, Mid-Continent area; **H. D. Babcock,** division engineer, Permian Basin Division.

Axelson-Garrett Division, U. S. Industries, Inc. — **Bolling A. Abercrombie,** manager-product planning.

National Tube Division, U. S. Steel Corporation — **Arthur W. Thornton,** director of engineering and research. In the Oil Well Supply division: **King D. Boyd,** transferred from Caracas to Dallas as sales representative; **J. W. Etheredge,** field representative, Hobbs, New Mexico; **R. T. Watkins,** area machinery sales manager, Los Angeles; **T. H. Scheline,** district representative, Wilson-Snyder Products, Inc., Chicago.

Waukesha Sales & Service, Inc. — **Frank L. Williams,** vice president and sales manager.

Mission Manufacturing Company — **Hugh L. Morris** and **Garland Kennon,** to sales staff.

The National Supply Company — **Arthur W. McKinney** retires after more than 40 years service that covered the span from salesman to the presidency in 1954; **John D. Mitchell,** plant sales engineer, Gainesville, Texas; **John F. Adams,** merchandising supervisor, Venezuela; **William T. Cushing Jr.,** assistant manager of the London, England, export division office; **Lester A. Carlson Jr.,** sales manager — production equipment, succeeding **Gerald R. Bond,** who has transferred to the Fluid Packed Pump Company division.

Otis Engineering Corporation — **Kenneth W. Robbins,** northern regional manager; **J. M. Prejean,** regional manager for the Texas Gulf Coast, headquarters in Dallas.

Halliburton Company — two division managers transferred: **W. L. Hughes,** from Midland to Oklahoma City, and **P. C. Mayfield,** from Oklahoma City to Midland.

Fluid catalytic cracking unit, Toledo (Ohio) refinery, Standard Oil of Ohio


# Refractory insulating concrete stops corrosion in this new FCC

In constructing the fluid catalytic cracking unit at Sohio's new Toledo refinery, corrosion resistance, abrasion resistance and insulation were built in right from the start. Refractory insulating concrete, bonded with LUMNITE calcium-aluminate cement, was used to line the regenerator, cyclones, stripper, catalyst and reactor transfer lines. Now on stream, these industrial concrete linings will resist severe erosion and abrasion caused by catalyst fines... resist attack by acid condensate... and provide insulation at high temperatures.

Installation of monolithic concrete linings is fast, easy, economical – whether cast in place, gunited or plastered. Concrete reaches service strength in 24 hours.

For added convenience, castables bonded with LUMNITE cement are available from leading manufacturers of refractories. These are packaged mixtures, ready for use with just the addition of water. For more information, write Universal Atlas Cement, 100 Park Avenue, New York 17, N.Y.

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***Shop Assembled for***
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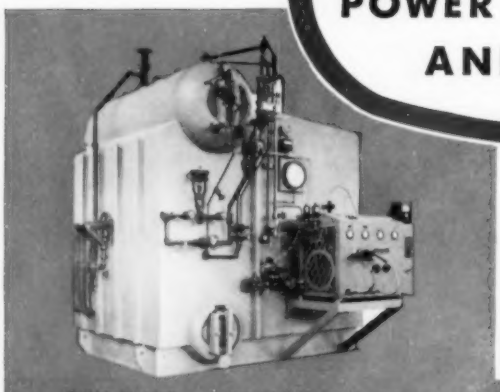

BOX PLANT — A 10,000 pounds/hour unit

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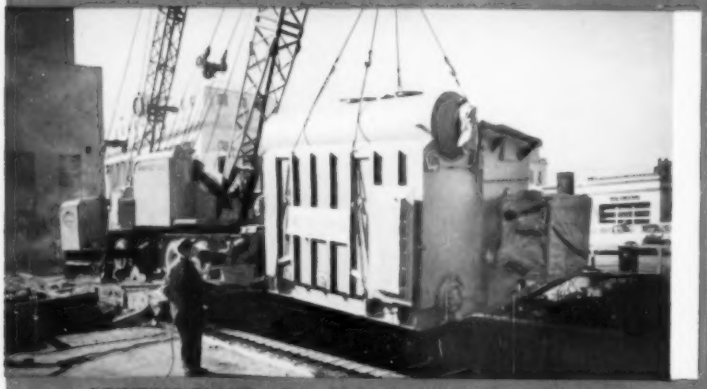

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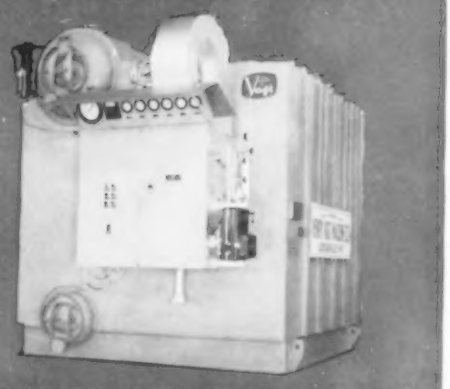

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# construction briefs

**Tennessee Gas Transmission Co.** will build a multimillion-dollar petrochemical plant on its Houston Ship Channel property. One unit will have initial capacity to manufacture 100,000,000 lb of acetylene annually from methane, while a second unit will convert a major part of the acetylene into vinyl chloride monomer.

**A huge complex to make** ethylene, naphthalene, benzene, and other chemicals from petroleum will be built on Chocolate Bayou, south of Houston by Monsanto Chemical Co. Installation will be designed to produce 500,000,000 lb of ethylene, 42,000,000 gal of benzene, and 50,000,000 lb of naphthalene annually, plus quantities of propylene, cumene, phenol, acetone, and ethyl benzene.

**A new gas plant** to be built at Sun Oil's Marcus Hook, Pennsylvania, refinery will be tied in with a consolidation of existing gas processing facilities at a cost of approximately $9,300,000. Plant will have an initial capacity to separate 14.4 MMcf of dry gas, 7100 bbl of liquefied propane and propylene, 13,200 bbl of liquefied butane, and 18,000 bbl of gasoline a day.

**Enjay Chemical Co.,** division of Humble Oil & Refining Co., has announced plans for expanded facilities that will "almost double" production capacity of benzene and toluene at the Baytown, Texas, refinery.

Continental Oil Co.'s new $1,000,000 plant at Ponca City, Oklahoma, will produce more than 20,000,000 gal annually of cyclohexane. Plant was constructed by Procon, Inc., Chicago.

**First privately financed helium extraction plant** in the United States to supply the commercial market will be built in the Pinta Field, Apache County, Arizona by Kerr-McGee Oil Industries, Inc. Plant will be designed to process 2.5 MMcf of gas per day.

**Suntide will build its sixth petrochemical** unit, a 30,000,000-lb-per-year ethyl benzene separation unit, at its Corpus Christi, Texas, installation. Badger Manufacturing Co. has contract for design, engineering, and construction.

**A construction program at Murphy Corporation's Superior, Wisconsin, refinery** will result in addition of a 5000-bbl-per-day fluid catalytic cracking unit, a 1200-bbl-per-day hydrofluoric acid alkylation unit, a 400-bbl-per-day increase in distillate fuel desulfurizing capacity, and an increase in gasoline treating capacity from 1500 to 4500 bbl per day.

**A new $35,000,000 petrochemical complex** at Zagreb, Yugoslavia, will produce polyethylene, styrene, polystyrene, phenol, and acetone for Organsko Kemijska Industrija (OKI). Foster Wheeler Corporation, New York, will provide detailed mechanical engineering and will supervise construction of the eight processing units.

**Societe de la Raffinerie d'Alger** will construct a 50,000-bbl-per-day refinery at Maison Carree, near Algiers, at a cost of approximately $47,600,000. Participants in the refining company are Compagnie Francaise des Petroles, CFP's refining affiliate Cie. Francaise de Raffinage, Shell Algerie, Esso Mediterranean, Societe Francaise des Petroles BP, SN-Repal, Mobil Francaise, and Beryl.

**Societe de la Raffinerie de Strasbourg SA** will build a 66,000-bbl-per-day refinery at Herrlisheim, about 15 miles north of Strasbourg, to supply marketing needs of northeast France, southern Germany, and Switzerland. Cost will be approximately $61,600,000.

A $7,500,000 expansion project nears completion at Husky Oil Co.'s Cody, Wyoming, refinery. New refining facilities include catalytic cracking and alkylation units. Cat tower rises to height of 174 ft.

**Sweden's first petrochemical industry,** representing a total investment of approximately $40,000,000, will be located at Stenungsund, on the west coast, north of Gothenburg. Svenska Esso AB will build a steam cracking plant to produce ethylene, propylene, and butadiene gases; a joint company formed by Union Carbide and Stockholm Superfosfat Fabriks AB, Sweden's largest electro-chemical industry, will produce polyethylene plastics, and the forest industry group, Mo och Domsjo, will construct a plant to produce ethylene oxide.

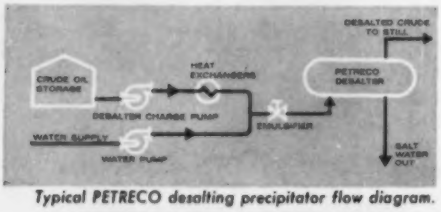
**ANIC-Gela, subsidiary of ENI,** will build a $161,000,000 plant at Gela, Sicily, to process about 3,000.000 metric tons of crude oil annually. Plant will be designed to reduce carbon content through coking process at high temperature which will yield petroleum coke, mixed hydrocarbons, and other gaseous residues. Products obtained will include about 30,000 tons of ethylene, sulfuric acid, and about 60,000 tons of urea.

**British American Oil** is installing a $1,000,000 carbon monoxide boiler and extraction steam turbine to supply power for a major portion of the Clarkson refinery, 20 miles west of Toronto, Canada.

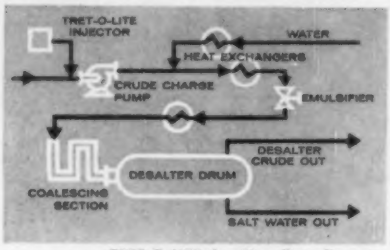
**Sun Oil** will build a $700,000 hydrodesulfurizer unit at its Sarnia, Ontario, Canada, refinery with capacity of 2600 bbl per day. Unit will produce heating oils with greater stability and lower sulfur content.

# How PETRECO Processes Work...

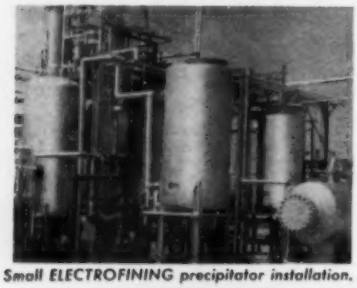
## TO IMPROVE PRODUCTS...CUT TREATING COSTS



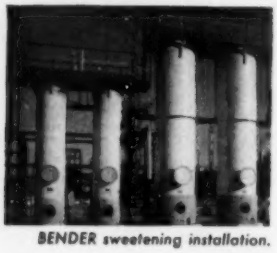

*Typical PETRECO desalting precipitator flow diagram.*




*TRET-O-LITE desalting flow diagram.*



*Small ELECTROFINING precipitator installation.*



*BENDER sweetening installation.*

** Trademarks, Petrolite Corporation*

## PETRECO *Electric Desalting*

The crude charge is pumped through a heat source with temperatures in the 225-275°F. range, then mixed with a small quantity of water and emulsified. Resulting water-in-oil emulsion is then dispersed into high-potential electrostatic field. Powerful coalescing action forces intimate association of impurities (salts and other solids) with water. Water is then quickly and automatically separated and withdrawn. Purified crude continues into refinery flow.

## Tret-O-litE *Chemical Desalting

Chemical is injected into suction side of charge pump to assure dispersion. Wash water (about 5% of oil volume) is added to oil-chemical mixture following the charge pump. This oil-chemical-water mix is raised to operating temperature and water-to-oil contact attained by passing through emulsifying valve following heat exchangers. Resulting emulsion then goes through coalescing section where water droplets grow to size that permits separation. Mixture then enters desalting vessel, salt-in-water separates from hydrocarbon phase. Purified crude proceeds to usual distillation equipment.

## ELECTROFINING *Precipitators

In this treatment, the distillate is intimately and intensively contacted with a predetermined amount of treating chemical. Controlled intimacy of contact minimizes treating time. The hydrocarbon and treating chemical phases then are rapidly separated by the precipitating action of the strong electrostatic field. With ELECTROFINING* Precipitators, distillate stocks can be treated with caustic to remove acids, hydrogen sulfide, lighter mercaptans, gum-forming components. Cracked stocks can be treated to remove cresols and thiocresols. Sulfuric acid treatment removes sulfur compounds, gum and sediment forming materials, nitrogen bases, arsenic, lead, etc.

## BENDER Catalytic Sweetening

Controlled quantities of sulfur, alkali and air are added to the charge stream, then passed through a PETRECO* catalyst bed. The mercaptans are converted to disulfides by oxidation. The resulting product is sweet and non-corrosive. The BENDER process is simple, continuous and automatic.

OTHER PETRECO PROCESSES INCLUDE:

**PETRECO** *Dehydration
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**PETRECO** *Sediment Separation

FOR MORE INFORMATION on any of these treating processes, contact your local Petreco service engineer, or write...

AR-60-2

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## at the A.I.Ch.E. Petrochemical and Refining Show...

**the place:** NEW ORLEANS, LA.

**the time:**

**FEBRUARY 1961**

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HELPFUL WATER CONDITIONING DATA FROM BETZ

# CORROSION CONTROL FOR

**The modern tools of corrosion control can reduce repair and maintenance costs in your boiler plant.**

CORROSION in the modern boiler plant can manifest itself in many locations; such as in the pre-boiler equipment, in the boilers and in the steam and condensate systems. Figures 1, 2 and 3 are typical illustrations of the damage done at some of these locations.

For the most part corrosion is due to dissolved oxygen. Other factors such as low pH values, carbon dioxide and ammonia may be involved, either alone or in conjunction with dissolved oxygen. The preventive measures required to adequately control corrosion involve mechanical equipment and/or chemical treatment.

## Mechanical Deaeration

The first line of defense in preventing corrosion is mechanical deaeration. As applied to boiler feedwater, this involves removal of dissolved oxygen in a vented heater by intimately mixing, scrubbing and heating the water with steam. The feedwater heater removes dissolved oxygen, decreases free carbon dioxide and elevates the feedwater to the saturation temperature of the steam. Since exhaust steam is used whenever available, boiler efficiency is also improved. Complex heater designs are required to secure maximum mechanical deaeration. The types of heaters employed include:

1. The *conventional open heater* is most frequently employed in the low pressure boiler plant and is designed to decrease dissolved oxygen to a range of 0.1-0.3 cc per liter.
2. The *deaerating heater* is a unit designed to decrease dissolved oxygen to concentrations of 0.03 cc per liter.
3. The *deaerator* is a unit designed to decrease dissolved oxygen to 0.005 cc per liter or less.

In plants that use simple receivers or open tanks in place of specially designed feedwater heaters, substantial amounts of dissolved oxygen will remain in the feedwater. For example, at atmospheric pressure and temperatures of 120 F, 150 F and 180 F, residual dissolved oxygen concentrations expected are 5.7, 4.3 and 1.5 ppm respectively. It is important therefore to maintain the feedwater temperature as high as possible for maximum removal of dissolved oxygen. The supplemental use of a chemical deaerant is essential in these plants to control corrosion and pitting due to dissolved oxygen. A second essential requirement is that the feedwater temperature be maintained at a consistently high level. Wide fluctuations in feedwater temperature would make it difficult, if not impossible, to regulate the feed of the chemical deaerant to cope with the varying concentrations of residual oxygen.

*Figure 1*—Pitting in boiler drum.

## Chemical Deaeration

Sodium sulfite is the chemical agent favored for chemical deaeration in all but the high pressure plants because of its low cost and ease of handling. Where speed of reaction is important a catalyzed sodium sulfite is available which will react instantaneously with dissolved oxygen. The reaction of sodium sulfite with dissolved oxygen is illustrated as follows:

$$2Na_2SO_3 + O_2 = 2Na_2SO_4$$

sodium sulfite + oxygen = sodium sulfate

To remove 1.0 ppm of dissolved oxygen approximately 10 ppm of technical grade sodium sulfite is required. The end product is sodium sulfate which adds to the dissolved solids content of the water, but is otherwise innocuous.

While chemical deaeration is essential where incomplete mechanical deaeration of the feedwater is accomplished, it is a much desired supplement even when employing specially designed feedwater heaters. The low additional cost of the chemical deaerant in these cases is justified as it provides:

1. Complete oxygen removal.
2. An added safety factor in the event of momentary interruptions in efficiency of mechanical deaeration.
3. Warning when the efficiency of mechanical deaeration is continuously low.
4. Protection of the pre-boiler equipment, such as feed pumps, feedlines, stage heaters and economizers.

*Figure 2*—Condensate line attack by carbon dioxide.

In many plants, the most suitable point of application is the storage compartment of the feedwater heater. In other plants, sufficient reaction time may be available with continuous feed to the suction side of the boiler feed pump.

As boiler operating pressures have increased, two disadvantages of sodium sulfite as a chemical deaerant have become evident. While the increase in dissolved solids produced by the end product sodium sulfate is of little consequence in low or medium pressure boilers, it can be of significance in high pressure boilers. Also, at high pressures, the residual sulfite required for control



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purposes, tends to decompose to form the acidic gases, sulfur dioxide and hydrogen sulfide which can contribute to corrosion in the steam and condensate systems. For these reasons, hydrazine finds favor as a chemical deaerant in high pressure boiler systems. Hydrazine removes dissolved oxygen in accordance with the following reaction:

$$\underset{\text{hydrazine}}{N_2H_4} + \underset{\text{oxygen}}{O_2} = \underset{\text{water}}{2H_2O} + \underset{\text{nitrogen}}{N_2}$$

Since the products of this reaction are water and nitrogen no dissolved solids are added to the boiler water. In addition, the decomposition products of the residual hydrazine are ammonia and nitrogen. The ammonia is alkaline and will not attack steel. However, it is essential to avoid high residuals of hydrazine otherwise the ammonia produced may have an adverse effect on copper and copper bearing alloys.

Except for special cases of corrosive attack involving high pressure boiler operation, experience has shown that it is desirable to maintain a minimum boiler water pH of approximately 10.5. This pH is sufficiently high to prevent corrosion of the boiler proper. Usually, in the low and moderate pressure range, boiler water alkalinity is set at sufficiently high levels primarily to assure the proper environment for precipitation of calcium and magnesium sludge. These levels assure at least the minimum pH necessary for proper protection of the boiler against acidic corrosion.

In high pressure boilers the alkalinity level is restricted to avoid "free caustic" and thus prevent embrittlement and other adverse effects.

Carbon dioxide has little bearing on corrosion of the pre-boiler system or the boiler proper. Efficient mechanical deaeration will decrease the free carbon dioxide of the boiler feedwater and as a result the pH of the feedwater will increase. The increase in pH thus produced together with the feed of a chemical deaerant usually affords adequate protection to the pre-boiler system. In some cases, the supplemental feed of caustic soda may be employed to further increase the pH of the feedwater and to speed the reaction of the chemical deaerant.

The concern with carbon dioxide is primarily due to its adverse effect in the steam and condensate system. The natural bicarbonate alkalinity of the feedwater decomposes when subjected to boiler temperature, yielding carbon dioxide which leaves the boiler with the steam. At points of condensation low pH will develop from the carbonic acid formed and corrosion will ensue. Prevention of steam and condensate corrosion can effectively and economically be accomplished by use of the film forming or neutralizing amines.

## Protection of Idle Equipment

All too often, little attention is given to idle equipment in the boiler plant until serious corrosion has developed. Special measures are necessary to protect idle boilers and steam turbines. The methods applicable depend on many factors but suitable procedures can be worked out for most conditions.

# THE BOILER PLANT

*Figure 3—Corrosion of turbine blades.*

## Other Factors

While mechanical and chemical deaeration will serve to cope with dissolved oxygen—the major cause of corrosion in boiler plants—pH and carbon dioxide are factors that must also be considered.


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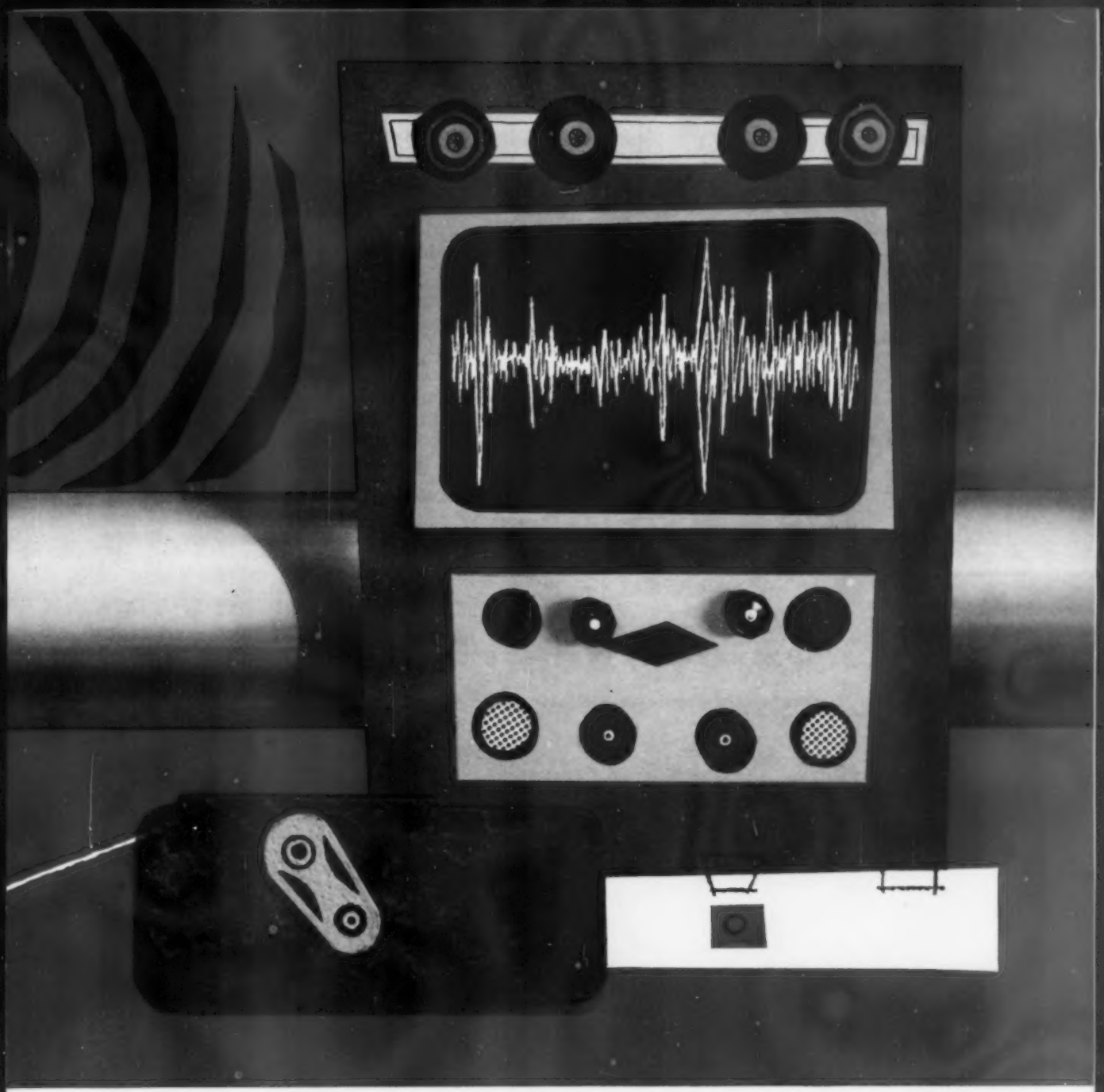

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# Oxidation processes in the

**PETER W. SHERWOOD**, *Chemical Engineer, White Plains, New York*

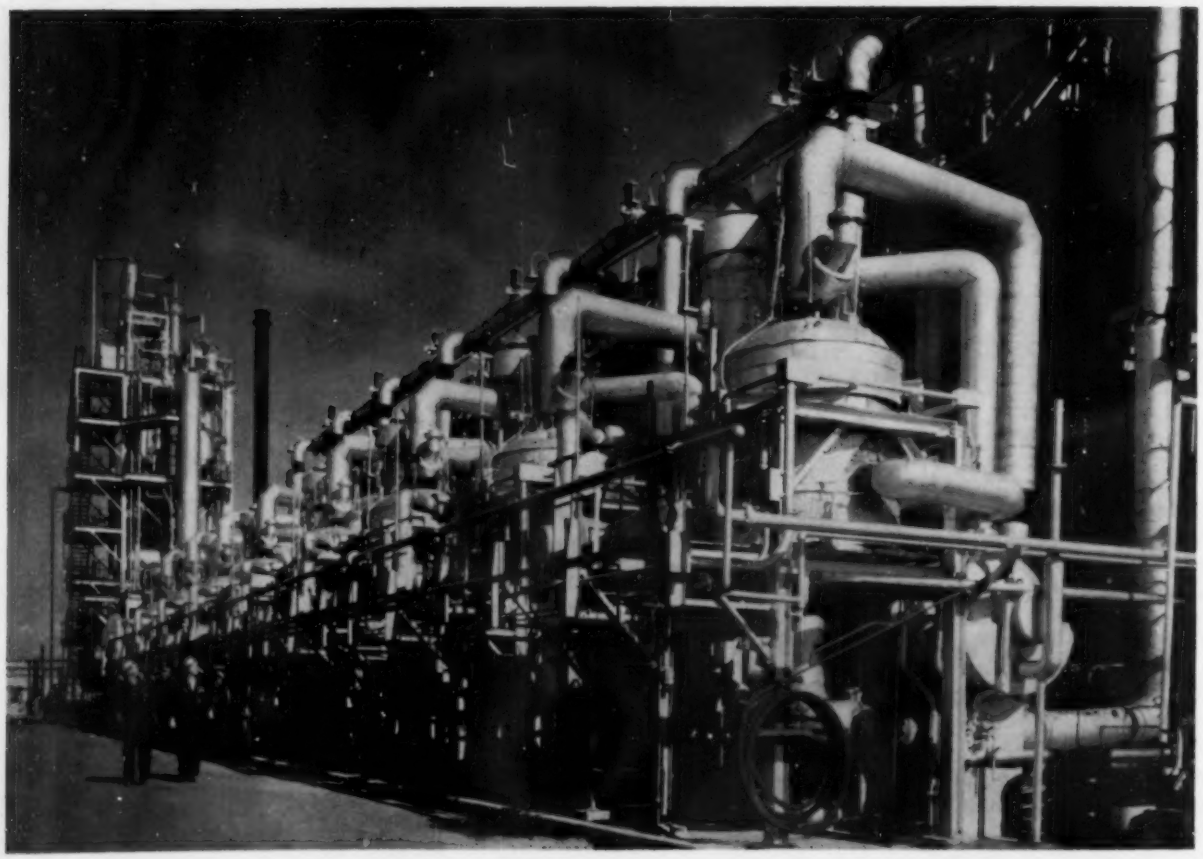
In the manufacture of petrochemical intermediates — as distinct from end use chemicals — more than 80% of production involves use of two related chemical reactions: oxidation and dehydrogenation. On a volume basis, dehydrogenation, which serves in the manufacture of ethylene, propylene, butadiene, styrene, etc., is the more important. But in point of versatility, oxidation is in a class by itself. A recent analysis shows that processes of this type are involved in the manufacture of 48 out of the 70 top petrochemicals produced in 1960.

Fundamentally, oxidation processes may serve four different purposes:

- Addition oxidation, in which oxygen atoms are added to the feed molecule. An example is the conversion of ethylene to ethylene oxide.
- Substitution oxidation, where an existing atom or group of atoms is replaced by one or several oxygen atoms. This is illustrated by the production of maleic anhydride from benzene.
- Dehydrogenation. In essence, the purpose here is to remove hydrogen from the feed molecule by conversion to water. Illustrative is the production of acetaldehyde from ethanol.
- Thermal effect. In some pyrolytic processes, e.g., the production of acetylene from methane, part of the feedstock is oxidized for the sole purpose of providing the heat requirements of the desired endothermic reaction.

For use in large-volume petrochemical operations, choice of **oxidizing agent** is essentially limited to air (or oxygen), nitric acid, and sulfur. By far the most important of these is molecular oxygen, employed in a whole gamut of commercial operations which range from manufacture of synthesis gas to the production of phenol, sulfur, ethylene oxide, and phthalic acids. Much more limited in scope is commercial oxidation by nitric acid, and here the most important examples are production of terephthalic acids and adipic acids. Finally, use of sulfur as oxidizing agent is confined to a special route employed commercially for production of isomeric phthalic acids. Furthermore, use of sulfur for the production of carbon disulfide from methane may, within its broadest definition, be viewed as a form of oxidation.

The organic root of various oxygenated petrochemicals is furnished by the whole series of lower hydrocarbons found in or derived from petroleum stocks. Table 1 lists the



most important derivatives obtainable directly by oxidation of various hydrocarbon feedstocks.

The oxidative conversions in Table 1 involve only direct derivation from the primary listed hydrocarbons. The range and economic impact of oxidative processes becomes even more significant if we extend our survey to second-and third-generation petrochemical derivatives. This would bring in the bulk of acetic acid production (via acetaldehyde), of formaldehyde (via methanol), acetaldehyde (via ethanol), caprolactam, etc.

Versatility as to raw materials source is illustrated by maleic anhydride which may be obtained by air oxidation of either benzene or butene-2. In its turn, benzene is derived only in part (currently about two-thirds) from petroleum sources, with the remainder recovered from coal coking operations.

An even more drastic divergence of raw materials choice is at hand in the case of acetylene. Only about 15% of this material is obtained by the oxidative pyrolysis of methane, while the bulk of production stems from the more conventional reaction between calcium carbide and water.

In the case of hydrogen production for ammonia synthesis five major sources are at hand: by-product of chlorine cells (3% of capacity), steam reforming of hydrocarbons (66%), partial oxidation of hydrocarbons (15%), by-product from refinery operations (13%), coke-oven gas (3%). These methods have taken over almost completely from coke reformers, which were the chief source of ammonia hydrogen until the end of World War II.

Regardless of technical purpose, oxidizing agent, feedstock, end product and detail of execution, oxidative processes fall into a few major categories. The following broad classifications may be distinguished:

| *Vapor Phase* | *Liquid Phase* | *Oxidizing Agent* |
|---|---|---|
| Thermal | — | Air, oxygen |
| Heterocatalytic | — | Air, oxygen, sulfur |
| (Homocatalytic) | — | Air, oxygen |
| — | Autocatalytic | Air, oxygen |
| — | Heterocatalytic | Air, oxygen |
| — | Homocatalytic | Air, oxygen |
| — | Non-catalytic | $HNO_3$ |
| — | Thermal | Sulfur |

The following discussion will be concerned with the commercial significance and various technical aspects of petrochemical oxidation processes in these categories.

# petrochemical industry

## PART 1. VAPOR-PHASE PROCESSES

**Table 1**

| *Feedstock* | *Principal Oxidation Derivatives* |
|---|---|
| Methane | Synthesis gas (for ammonia, methanol, oxo products)<br>Acetylene<br>Hydrogen cyanide<br>Carbon disulfide |
| Ethane-ethylene | Ethylene oxide<br>Acetaldehyde* |
| Propane-propylene | Acrolein<br>Acetone* |
| Butane-butylene | Acetic acid<br>Acetaldehyde*<br>Formaldehyde*<br>Methanol*<br>Maleic Anhydride* |
| Cyclohexane | Cyclohexanone<br>Adipic acid |
| Benzene | Maleic anhydride |
| Toluene | Benzoic Acid |
| Xylenes | Isomeric phthalic acids |
| Etnyl benzene | Acetophenone<br>Methyl phenyl carbinol |
| Cumene | Phenol*<br>Acetone* |
| Naphthalene | Phthalic anhydride |

*Produced to a greater extent by alternative routes.

### Thermal methods

The combustion of hydrocarbons and their aliphatic derivatives proceeds via a complex reaction chain to carbon dioxide and water. Partial oxidation methods carried out thermally (i.e., at high temperature, in the absence of catalyst) in the vapor phase are directed toward interrupting the combustion chain at some point short of completion at which the desired end product is present in economically recoverable concentration. With one exception — the production of synthesis gas in which the product is thermally stable — this approach to partial oxidation calls for critically accurate control over residence time in the high-temperature zone. Furthermore, there may be no contact between the reaction phase and catalytically active surfaces which would promote degradation of the desired oxidation product.

In functional terms, vapor-phase thermal oxidation serves in three categories. Foremost importance attaches to substitution reactions, namely production of synthesis gas and conversion of lower paraffins to oxygenated organic derivatives. Partial combustion serves for thermal effect in the production of both acetylene and synthesis gas and has been investigated for the production of ethylene. Finally, isopropanol can be reacted thermally with air to yield hydrogen peroxide and acetone as co-products.

**1. Synthesis gas**

Synthesis gas is a mixture of carbon monoxide and hydrogen, produced in various degrees of purity. Principal chemical uses for the gas are the manufacture of methanol, ammonia, Oxo alcohols and various hydrogenated products. At one South African plant (SASOL), synthesis gas obtained by coal gasification serves for production of hydrocarbons — a use which was of importance in Europe during World War II.

The importance of synthesis gas to ammonia and other hydrogenation processes depends on the readiness with which it can be converted to hydrogen of high purity. This conversion involves the reaction of carbon monoxide with

←

FIG. 1. Oronite Chemical Company's plant for the vapor phase oxidation of ortho-xylene to phthalic anhydride.

steam under controlled conditions to yield hydrogen and carbon dioxide which can be readily separated.

The basic approach in converting hydrocarbons to synthesis gas involves steam reforming ($CH_4 + H_2O = CO + 3H_2$). This reaction is highly endothermic, and heat requirements are met by passing the process stream through a fired pipestill. In an alternative approach, a portion of the process hydrocarbon is burned by air (if nitrogen in the product is not objectionable), or by oxygen; i.e., combustion reactions are allowed to proceed concurrently with steam reforming. By suitable adjustment of the steam:hydrocarbon:oxygen ratio, reaction temperature can be adequately controlled and, at the same time, the ratio $(CO + H_2)/(CO_2 + H_2O)$ in the primary product can be adjusted.

Several modifications of the partial oxidation process are practiced. They differ principally in number of reactor stages, operating pressure, and presence or absence of catalyst. Purely thermal processes, such as those developed by Shell and Texaco, operate at 1100 to 1500C and at 450 to 600 psi. Feed hydrocarbon may range from methane to fuel oil; tonnage oxygen serves as oxidizing agent.

BASF and others have developed semi-catalytic processes for oxidation-reforming of hydrocarbons to synthesis gas. Here the initial reaction proceeds thermally but the reactor gases pass over a nickel catalyst to complete methane conversion to the equilibrium limit.

**2. Oxygenated aliphatic chemicals**

Thermal oxidation of lower paraffins to yield oxygenated organic derivatives is practiced commercially in the United States only by Celanese Corporation (at Bishop, Texas). Three other ventures in this field have been operated in the past by Cities Service, Warren Petroleum, and McCarthy Chemical Company. Reactant gases at Celanese Corporation's plant are air and a butane-propane mixture.

The partial oxidation of paraffins is susceptible to over-oxidation, side reactions, and product degradation, and close control must be exerted over reaction conditions. Key variables are inlet gas composition and method of mixing the reactants, total system pressure and partial pressure of reactants, residence time and, of course, operating temperature.

In a typical process scheme, 95% oxygen and feed hydrocarbons are mixed by a sparger in the hydrocarbon line. A high enough ratio of hydrocarbon:oxygen is maintained to keep oxygen concentration below its lower explosive limit in the mixture. The preheated mixture is fed to the reaction chamber.

Immediately following the converter, the effluent gases are quenched to not more than 180 C by a water spray. After further cooling and condensation, the products are ready for separation.

Yield and product composition are, of course, subject to wide variations as a function of changes in operating conditions. For the Celanese process, in its pre-1957 version, which used air instead of 95% oxygen as oxidizing agent and butane as feedstock, Meyer[1] reported the following distribution as typical: formaldehyde, 1.6 lb per gal hydrocarbon; acetaldehyde, 1.5 lb; methyl alcohol, 0.98 lb; acetone, 0.20 lb; other, 0.60 lb.

The wide range of products which can be obtained by thermal partial oxidation of hydrocarbons is illustrated by Jones[2] who reports formation of 60 to 70 lb oxygenated products per 100 lb $C_6$-$C_{16}$ hydrocarbons reacted. In this study, good temperature control was achieved in the reactor by injection of inert solid particles. The organic products were principally epoxides, aldehydes, and some alcohols.

Investigators at Escambia Chemical Corp.[3] have reported the laboratory production of ethylene oxide, acetaldehyde, formaldehyde, and ethylene by partial oxidation of ethane. Operating at a .45 molar ratio of oxygen:ethane and with a wall temperature of 443C in an empty Vycor reactor, total carbon distribution is reported as follows: ethylene, 57.3%; acetaldehyde, 11.0%; ethylene oxide, 10.0%; formaldehyde, 11.5%.

**3. Acetylene and ethylene**

During the years 1949 to 1959, consumption of acetylene in the U. S. has grown from 180,000,000 to 850,000,000 lb. Almost the entire growth has come from chemical demand, chiefly from vinyl chloride (32% of 1959 consumption), acrylonitrile (16%), neoprene (27%) and vinyl acetate (8%).

Some 12 to 15 percent of current acetylene production is based on pyrolysis of methane. Total U.S. capacity for methane-derived acetylene, spread over five plants, is approximately 250,000,000 lb per year.

The last few years have seen extensive activity in the development of techniques for the manufacture of acetylene from methane and other petroleum hydrocarbons. In each instance, the principal is the same; the hydrocarbon feedstock is heated to 1400 to 1450C and, following on exposure time of 0.003 to O.01 sec, it is quenched immediately to limit the occurrence of breakdown reactions which will destroy the desired product.

To provide heat for the highly endothermic (6600 Btu per lb acetylene from methane) reaction, all commercial plants use the partial combustion principle. Processes are available in which air serves as oxidizing agent, (e.g., Tennessee Eastman's two-stage reactor and Phillips Petroleum Company's "tangential reactor"). However, oxygen is employed predominatly as oxidizing agent, despite its higher cost. Advantages of oxygen are: higher thermal efficiency in pyrolysis, a reactor product which is more concentrated in acetylene, and the formation of by-product synthesis gas in usable form.

Commercial processes for acetylene production from methane and oxygen have been developed by BASF, Union Carbide, Societe Belgique d'Azote (SBA), and Montecatini. The various methods differ in details of burner design, operating pressure, and in the system employed for recovering acetylene from the burner gas in which its concentration is only 7 to 9%. Commercial absorption systems for acetylene include aqueous gamma-butyrolactone (BASF) and liquid ammonia-methanol (SBA). Of interest are also dimethyl formamide, acetone, acetonyl acetone ,etc.

Typical raw materials and utilities consumption per pound acetylene is 116 std cu ft methane, 5.2 lb oxygen (95% basis), 13.3 lb steam, 140 gal cooling water, 0.17 Kwhr electricity.

For the conversion of higher hydrocarbons to acetylene, special interest attaches to two-stage processes. Here, a fuel gas is burned with its stoichiometric equivalent of preheated air or oxygen to reach a flame temperature of 2000C. In a second stage, the process hydrocarbon is injected into the hot flue gas. Following a short residence time in the reaction zone, the gas product is quenched and processed for acetylene recovery. The first commercial plant based on this principle is a 100,000,000 lb per year acetylene-and-ethylene plant, now being operated by Germany's Farbwerke Hoechst.

Production of ethylene per se by partial oxidation of gaseous paraffins is not today practiced. However, one such process, using oxygen and ethane, has been operated during the war at Leuna, Germany, and an air-ethane process has been piloted by Universal Oil Products Company.

**4. Hydrogen Peroxide**

Partial oxidation of hydrocarbons and lower aliphatic alcohols can be directed toward the formation of hydrogen peroxide. Details of the technique are reported by the author elsewhere in this journal[4].

Of special interest is the thermal, vapor-phase oxidation of isopropanol to acetone and hydrogen peroxide. Air serves

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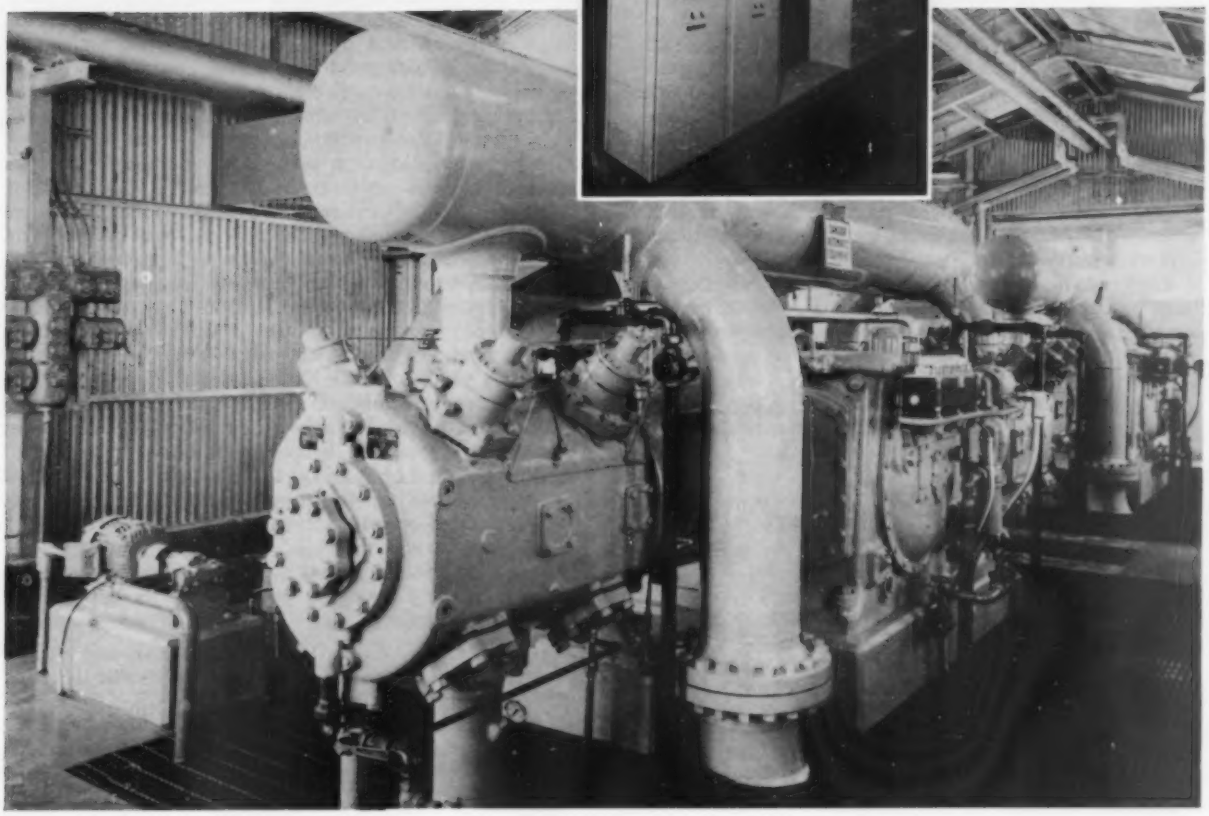

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as oxidizing agent. Typical alcohol:oxygen feed ratio for high efficiency is about 5:1.

Overall feasible temperature range for the reaction is 350 to 500 C. For a given set of conditions (feed alcohol, reactants' ratio, contact time), an optimum temperature exists which must be controlled within narrow limits.

Best performance has been reported at a per-pass conversion in the range of 60 to 80% of initial oxygen. Typical contact time for such conversion is between 0.5 and 1.0 sec (calculated at NTP). Contact must be avoided with metals which will promote decomposition of hydrogen peroxide, such as iron or copper. According to Harris[5], particularly good performance is obtained by the use of acidic enamels as internal reactor surfaces.

It is important that the reactor make be quenched quickly to a temperature below 100C. Water injection at this point has the dual advantage of providing quick cooling and of diluting condensed hydrogen peroxide below the point where an explosion hazard is created in the presence of organic materials.

The crude liquid reaction product is topped for the overhead removal of the alcohol-water azeotrope, which is recycled. At the same time, co-product ketone and other light boilers are taken off.

Hydrogen peroxide yield in vapor phase oxidation at the most favorable reported conditions is about 0.7 moles per mole isopropanol consumed. Approximately 0.9 moles acetone are formed as co-product.

### Heterogeneous catalysts

The use of solid catalysts to direct the partial oxidation of hydrocarbons and their primary derivatives is of paramount importance in petrochemical operations. Methods of this type are employed in the synthesis of about 12 chemicals with individual production volumes in excess of 20,000,000 lb per year. The present paper will consider commercial and semi-commercial processes in this category according to class of end product. The following types of reaction will be considered:

| *Class of End Product* | *Feedstock* | *Example* | |
|---|---|---|---|
| Aldehydes | Olefin | Propylene→ | Acrolein |
| | Alcohol | Methanol→ | Acetaldehyde |
| Acids and anhydrides | Aromatic hydrocarbon | Benzene→ | Maleic anhydride |
| | Olefin | Butene→ | Maleic anhydride |
| Epoxides | Olefin | Ethylene→ | Ethylene oxide |
| Miscellaneous | Ammonia & hydrocarbon | Ammonia & methane→ | Hydrogen cyanide |
| | Hydrogen sulfide | Hydrogen sulfide→ | Sulfur |
| | Sulfur & hydrocarbon | Methane & sulfur→ | Carbon disulfide |

In the Vapor-phase oxidation processes to be considered below, either air or oxygen may serve as oxidizing agent. Where only partial conversion is taken per pass, as is the case in ethylene oxide production, the use of oxygen permits more complete recycle of unconverted feedstock because only very small quantity of inert gas must be bled from the system. However, in other types of partial oxidation process, the high cost of oxygen has not so far been justified by yield improvements and simplification in reaction equipment.

The principal side reaction in vapor-phase partial oxidation is the complete combustion to carbon dioxide and water. Obviously, operating conditions must be directed toward holding such complete combustion at a minimum for two reasons: the attendant yield loss and the very high exothermic heat evolved by complete oxidation. For example, the partial oxidation of one pound ethylene to ethylene oxide results in evolution of 1800 Btu, while the complete combustion of the same amount of ethylene is accompanied by formation of 20,300 Btu.

Even under the best operating conditions, oxidation processes generate considerable heat and one of the main problems in reactor design is its adequate heat removal. In fixed-bed catalysis, the usual approach is to mount catalysts inside the tubes of a shell-and-tube reactor and, to circulate cooling medium through the shell.

Because of its excellent heat exchange properties, fluidized-bed operation has been considered for almost all the vapor-phase catalytic oxidation processes. Advantages of this system include good temperature control, less danger of explosion at lower air-hydrocarbon ratio, ease of heat removal and simplicity of feed preheat. In practice, however, this approach has found only very limited application, largely because abrasion and loss of the costly catalysts involved imposes too large an economic burden. Furthermore, fluidized-bed catalysis in oxidation processes suffers from relative inflexibility in throughput, and from erosion of the reaction equipment. Thus, this approach to heat removal from partial oxidation processes is presently limited in commercial practice to five phthalic anhydride plants in the U.S. and England. In the case of ethylene oxide production, a fluid-bed process has been developed through an advanced pilot plant stage.

Two processes to be discussed (namely, oxidation-dehydrogenation of lower alcohols to the corresponding aldehydes and synthesis of hydrogen cyanide from methane) are characterized by such high reaction rates that the catalyst is employed only as a very thin layer or as a gauze. In these instances, high operating temperatures are involved.

Although a wide range of catalysts is covered by the patent literature for partial oxidation in the vapor phase, catalysts in large-scale petrochemical service is limited to the following kinds:

| *Base Material* | *Process* | *Functional Service* |
|---|---|---|
| Silver | Aldehydes from alcohol | Dehydrogenation |
| | Ethylene oxide from ethylene | Addition |
| Molybdenum oxide | Formaldehyde from methanol | Dehydrogenation |
| Vanadium pentoxide | Phthalic anhydride from naphthalene or o-xylene | Substitution |
| | Maleic anhydride from benzene | Substitution |
| Copper | Acrolein from propylene | Substitution |
| | Ethylene dichloride from eythylene and HCl | Dehydrogenation |
| Bauxite | Sulfur from $H_2S$ | Dehydrogenation |
| | Carbon disulfide from methane and sulfur | Substitution |
| Platinum | Hydrogen cyanide from methane and ammonia | Substitution-dehydrogenation |

Within each category of catalyst, there are some variations as to carrier material, promoter, and method of formulation.

Steps must be taken to keep the reaction systems free of iron oxides which promotes complete combustion to carbon dioxide and water. Toward this end, alloy steel tubes are used in some instances (most particularly in the oxidation-dehydrogenation of alcohols over silver catalyst). However, for economic reasons, carbon steel tubes are generally employed. Precaution must therefore be taken at the time the tubes are filled with catalyst to ensure that any adhering rust is removed.

Tolerance of other impurities varies with the process. In ethylene oxide synthesis, sulfur, diolefins, and acetylene harm the catalyst. Performance in phthalic anhydride production is favored by use of a fairly high grade naphthalene (76 to 79C melting point is the usual minimum commercial specification), and recent trend has been toward near-complete elimination of sulfur from the feedstock. In auto-

thermic hydrogen cyanide synthesis, the process feed must be free of sulfur, metal carbonyls, and higher hydrocarbons.

## PROCESSES

### Aldehydes

1. **Acrolein,** produced in the partial oxidation of propylene, serves as intermediate in Shell's new process for the synthesis of glycerine. In addition, promise is shown by acrolein polymers which are now in the pilot plant stage. Other outlets include production of glutaraldehyde, methionine, acrolein dimer, etc.

To yield acrolein, propylene is reacted with air in the presence of supported copper oxide catalyst. The reaction is carried out with excess propylene at 350 to 400C. and at a pressure up to 250 psi. Per-pass conversion of propylene is about 25% and yield of acrolein is reported in the range of 75 to 80%.

Reactor effluent is quenched and is then scrubbed with water at 150 to 250 psi and 10 to 30C. Acrolein and other light boilers are stripped off from the rich liquor and the stripper overhead contains 80 to 90% acrolein, 3 to 10% acetaldehyde plus some propionaldehyde, acetone, etc. Final purification is accomplished in a series of fractionation and extractive distillation steps[6].

Most recently, Standard Oil Company (Ohio) has shown interest in commercializing a propylene-to-acrolein process in which a bismuth-phosphorous-Molybdenum catalyst is employed.

Using 50% $Bi_9PMo_{12}0_{25}$ on silica, the process employs essentially stoichiometric ratio of propylene to air and calls for addition of about 3.5 moles steam per mole propylene. Operation at 450C, 1 atmosphere, and 1.6 sec contact time permits 56% single-pass conversion of propylene to acrolein. Over-all conversion of propylene to oxygenated products is reported to be 92.5% at these conditions.

2. **Conversion of lower alcohols** to the corresponding aldehyde by oxidation is practiced principally in the production of formaldehyde from methanol. Two approaches are employed: straight oxidation and combined oxidation-dehydrogenation. In both cases, air is the oxidizing agent. Commercially predominant is combined oxidation-dehydrogenation. Here, metallic silver serves as catalyst, and conversion is carried out at 600 to 660 C. Feed gas to the catalyst zone is an air-methanol mixture containing 40 to 50 vol. % methanol. Careful temperature control in the reaction zone is essential and is exercised by adjustment of reactants' ratio. A per-pass conversion of 55 to 60% is taken. Reaction yield is between 87 to 92%.

The straight oxidation of methanol is practiced at one or two U.S. plants. Here, the catalyst is iron-promoted molybdenum oxide. The reactor feed contains 5.5 to 8% methanol air and, depending on feed composition, the catalyst temperature is 300 to 400 C. Formaldehyde yield in the straight oxidation process is about 90%.

Advantages of straight oxidation are the high formaldehyde yield which is possible in essentially single-pass operation. Main drawback is the high cost of product recovery and purification which is due to the low formaldehyde concentration in the reactor effluent.

In the case of acetaldehyde production from ethanol, striaght oxidation is not practiced. In this instance straight dehydrogenation, which is not applicable to formaldehyde production, is commercially significant. Also practiced is oxidation-dehydrogenation using techniques similar to those outlined above for formaldehyde. Unsupported silver serves as catalyst, operating temperature is 550 to 570 C. per-pass conversion is 50 to 55% and acetaldehyde yield is reported at 85 to 90%[7].

### Acids and anhydrides

1. **Phthalic anhydride** is produced almost entirely by the vapor phase oxidation of naphthalene and ortho-xylene. (One U. S. plant, operated by Amoco Chemical Co., is designed to produce phthalic anhydride by liquid phase oxidation.)

In the U. S., naphthalene is by far the predominant feedstock and accounts for 90 to 93% of the 385,000,000 lb phthalic anhydride output estimated for 1960. It should be noted that this preponderant use of napthalene does not apply everywhere; by 1961 an estimated 300,000,000 lb o-xylene will be exported from the U. S., chiefly to Japan and Italy, for conversion to phthalic.

Commercial oxidation of either naphthalene or ortho-xylene in the vapor phase is carried out over promoted vanadium pentoxide on an inert carrier. Both fixed-bed and fluid-bed catalytic reactors are employed.

In the more prevalent fixed-bed operation, the reactor feed contains 25 to 30 lb air per pound naphthalene. Operating temperature is 350 to 500 C depending on catalyst formulation and age. Contact time is .5 to 1 sec in the oxidation of naphthalene using fused or alundum-supported vanadium oxide catalysts. Typical phthalic yield is 95 to 100 lb per 100 lb naphthalene.

A by-product of phthalic anhydride is maleic acid which is recovered and converted to its anhydride in some installations.

2. **Maleic anhydride,** with a 1959 production volume of 53,000,000 lb, finds its principal outlet in the production of polyesters and alkyd coating resins. It was undersupplied until early 1960, but a spate of construction projects will raise U. S. plant capacity for maleic from 129,000,000 lb per year at year-end 1960 to 243,000,000 lb in late 1961.

Some 5% of total maleic output is recovered as by-product from phthalic anhydride manufacturing operations. The remainder is currently produced by the air oxidation of benzene. Furthermore, a 30,000,000 lb per year plant is now being built for Petro-Tex Corporation to produce maleic anhydride by the partial oxidation of butene-2.

**Oxidation of benzene** bears much similarity to the method for the production of phthalic anhydride. In this instance, the catalyst is molybdenum trioxide-promoted vanadium pentoxide on an inert carrier. Oxidation is carried out in the vapor phase and all existing plants use a fixed-bed catalyst arrangement.

The feedstream to the catalyst contains about one pound benzene per 325 std cu ft air (i.e., benzene concentration is below the lower explosive limit).

Various methods of recovery are practiced and these are described elsewhere[8]. Methods which employ water as scrubbing medium for the product maleic anhydride yield fumaric acid as by-product. Current market for this compound is in the 10 million pounds-per-year range.

**Oxidation of butene-2** constitutes a new commercial approach to maleic anhydride production. Among the advantages claimed are use of a lower-cost raw material and formation of less carbon dioxide and water, with attendant reduction in the heat removal problem.

Details of the Petro-Tex process for butene oxidation have not become available. However, previous work[9] on butene oxidation has centered on $V_2O_5$ - $P_2O_5$ catalysts on alumina, and a yield of 56% maleic anhydride on the hydrocarbon charge has been reported. A different approach[10] claims the use of cupric chloride as catalyst for this reaction.

### Epoxides

Among epoxides, only ethylene oxide is produced by vapor-phase oxidation. The method competes with the older chlorohydrination route.

As of mid-1961, oxidation plants will account for 60% of installed ethylene oxide capacity in the U. S.

The 1960 output of ethylene oxide is estimated at 1.5 billion lb. Of this total, 61% went into production of the antifreeze ethylene glycol. The remainder served as intermediate in the production of nonionic surfactents (11%), ethanolamines (10%), polyethylene glycols (9%), acrylics, glycol ethers, etc.

In all commercial ethylene oxidation processes, this olefin is reacted with molecular oxygen in the presence of supported metallic silver catalyst. In each instance, ethylene concentration in the reactor feed is in the range 3 to 5%; i.e., below the explosive limit. Admixture of low concentrations (less than 1 ppm) of ethylene dichloride to the feed gas is practiced to minimize complete combustion reaction.

Several versions of this basic approach to ethylene oxidation are practiced commercially[11]. Illustrative of air oxidation methods is the process of Scientific Design Company which is carried out on a once-through basis in two reactor stages, set in series. In the first reactor, relatively mild operating conditions aim at maximum yield of ethylene oxide. Following removal of this product by water scrubbing, the residual, unconverted ethylene is taken through a second reactor where it is subjected to more drastic, less selective conditions for maximum conversion. Overall yield in this process is reported at about 65% of theory.

Another commercial ethylene oxide process, developed by Shell, employs 95% oxygen in lieu of air. A single reactor serves. In this method, tail gas from the ethylene oxide recovery stage is continually recycled to the reactor for conversion of residual ethylene. Conditions inside the reactor are relatively mild, aiming at top yield rather than maximum per-pass conversion.

In principle, therefore, use of oxygen permits higher utilization of ethylene and a simpler reaction and recovery system in the ethylene oxide unit than is possible in air oxidation. On the debit side for oxygen-consuming processes is the investment and operating cost incurred in the oxygen generating plant.

### Miscellaneous

1. **Sulfur.** Hydrogen sulfide, recovered from sour natural or refinery gases, is oxidized to elemental sulfur by reaction with air. The usual catalyst is a natural bauxite (such as Porocel), but synthetic activated bauxite is also employed.

The conversion is carried out in two stages. One-third of the feed hydrogen sulfide is burned thermally to sulfur dioxide and this product is allowed to react in the presence of bauxite catalyst with the remaining $H_2S$ to form elemental sulfur. By this separation, the bulk of heat evolution takes place in the non-catalytic high temperature combustion furnace in which heat removal is simpler and steam can be generated.

The catalytic oxidation is effected at 200 to 400 C. Usually two or three catalytic stages are employed. The first of these is run at about 400 C, mainly to convert contained carbonyl sulfide, and the second and third reactors are operated at 230 C. Typical sulfur recovery is 93% in a two-stage operation.

2. **Nitriles.** Of outstanding commercial importance is the production of hydrogen cyanide by partial oxidation of methane and ammonia in the presence of air [13]. The reaction is carried out by passing the mixed feed gas through rhodium-promoted platinum gauze which serves as catalyst. The gauze temperature is about 950 to 1000 C. Operating pressure in commercial practice ranges from slightly negative to 40 psig.

Both thermal and chemical performance are controlled by adjustment of feed composition. Typically, the gas entering the reaction zone contains 11 to 12% ammonia, 12 to 13% methane, 2 to 3 % hydrogen. The remainder is air.

Useful conversion in a single pass is limited to about 60 to 70% of the ammonia. Unconverted ammonia may be separated from HCN and recovered by an absorption-stripping operation using an aqueous solution of boric acid-pentaerythritol complex as solvent. Alternatively, the ammonia may be absorbed in sulfuric acid and then recovered in the form of saleable ammonium sulfate. In a process of the latter kind typical raw materials consumption per pound hydrogen cyanide is 1.05 lb ammonia of which .3 lb is recovered as ammonium sulfate.

During 1959, Sohio Chemical Company announced construction of a plant for the production of 40,000,000 lb per year **acrylonitrile** by the single-step catalytic air oxidation of ammonia and propylene. Only very limited details of this process have become available. A Belgian patent application suggests the use of bismuth phosphomolybdate catalyst. As reported by Sohio at the autumn 1960 meeting of AIChE, the conversion is carried out in a fluid-bed reactor operated below 500 C and at around 2 to 3 atmospheres. Main by-products of the reaction are hydrogen cyanide and acetonitrile.

In another process for the direct synthesis of acrylonitrile from ammonia, propylene, and air, Distillers Co., Ltd. calls for the use of a catalyst containing oxides of molybdenum and cobalt. Still another process for the one-step conversion of propylene to acrylonitrile has been announced by DuPont. In this instance, the reaction is carried out between propylene and nitric oxide.

3. **Ethylene dichloride.** A process of interest is the chlorination of ethylene by HCl in the presence of air. Purpose of this approach is to recover chlorine values from by-product HCl (the conventional route to ethylene dichloride employs direct reaction between elemental chlorine and ethylene).

The partial oxidation method employs copper-based catalysts. Particularly high EDC yield is claimed by Reynolds[15] for catalysts containing 2 to 10 wt % copper silicate on a porous adsorptive siliceous base. Over such catalysts, ethylene chlorination by HCl plus air at 310 C is reported to achieve 96% conversion of HCl and 52% conversion of the hydrocarbon. The organic product contains about 80% EDC.

### Homogeneous catalysis

This approach to vapor phase oxidation has been employed for the production of formaldehyde from methane at a plant operated during the early 1940's by Gute Hoffnungshuette at Copsa Mica (Rumania).

The process used a fresh feed of 1.0 part methane and 3.7 parts air, together with 0.08% nitric oxide as catalyst. The reaction was carried out at 400 to 600 C. Low per-pass conversion was used so that a feed-to-recycle ratio of 1:9 was necessary. Yield of 35%, based on methane consumed, was achieved.

Another instance of homogeneous catalysis is the addition of hydrogen bromide to a paraffin-air mixture. This will direct the oxidation reaction to preferential attack on tertiary and secondary carbon atoms, in the order stated. In the case of propane oxidation it becomes possible to obtain predominantly acetone. Chief drawback of the process is the high loss of HBr which may be as much as 5 volume percent of reacted hydrocarbon.

HBr catalysis is also of interest for the vapor phase oxidation of toluene to benzoic acid. In a process described by Rust[14] a mixture of two volumes toluene vapor, two volumes oxygen, two volumes nitrogen, and one volume hydrogen bromide is reacted at 200 C, with a residence time of about three minutes. No information is available on yield on toluene. Useful conversion of oxygen to benzoic acid is stated to be 91.3%. Significant HBr loss is incurred.

(Part II—Liquid-Phase Processes—will appear in a subsequent issue.)

Stroboscopic photo shows fast, smooth quarter turn closure of Rockwell-Nordstrom lubricated plug valves.

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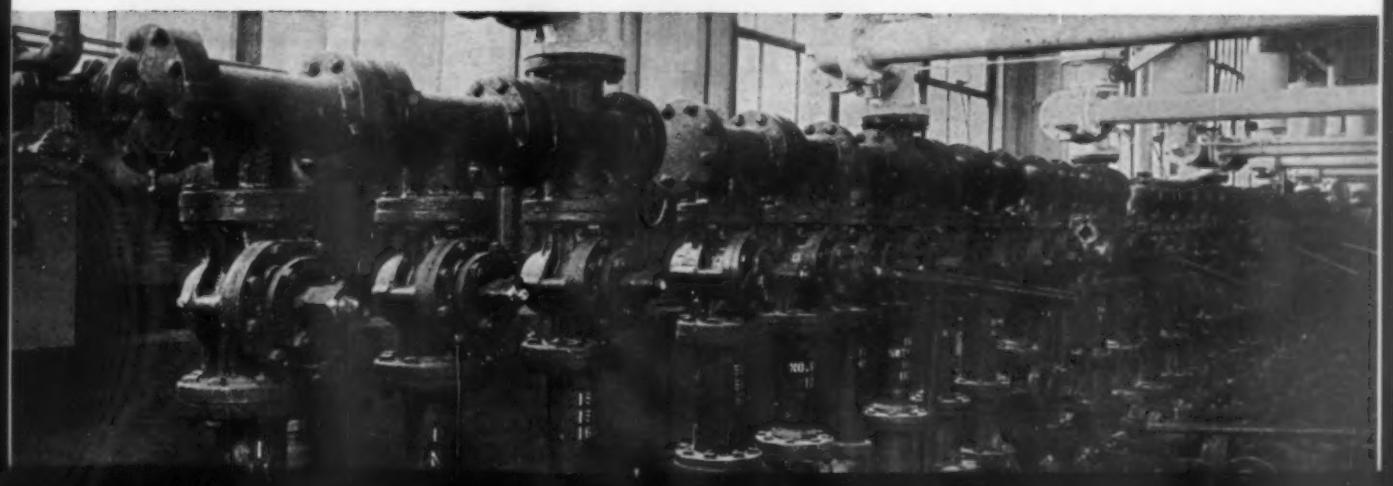

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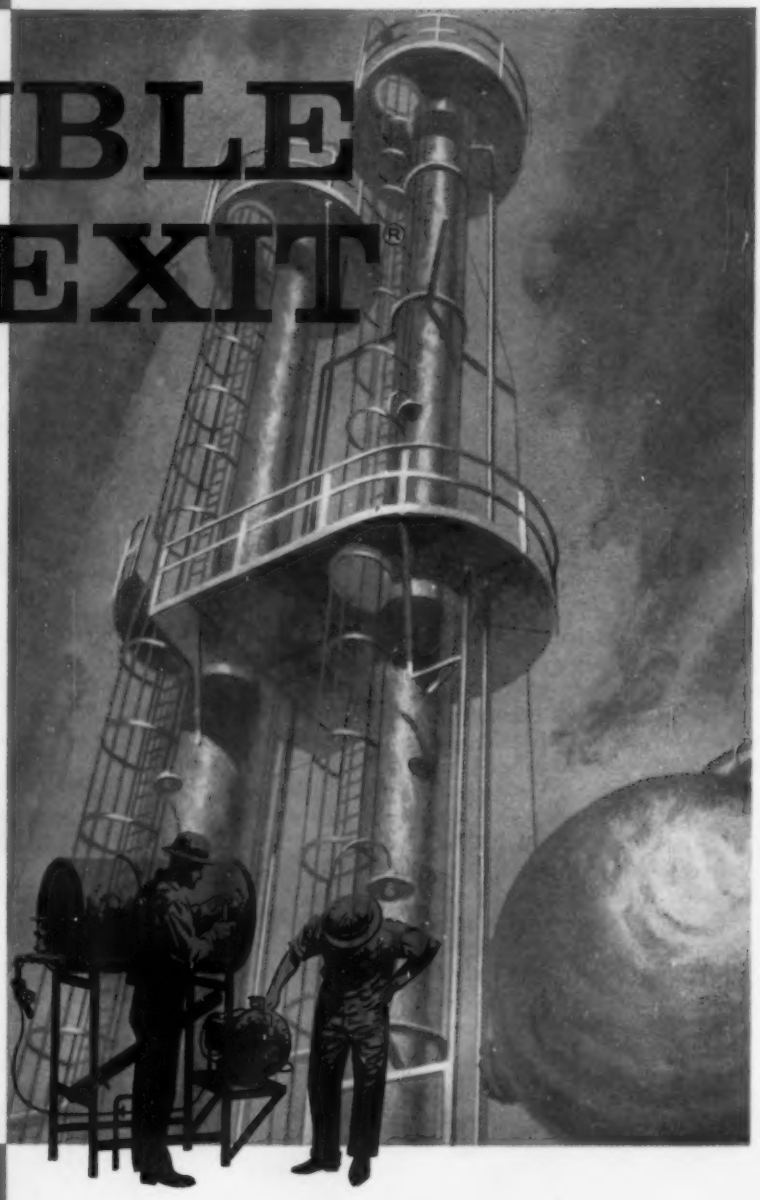

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**D. F. BRUCE**, *Section Manager, Industrial Gas Turbine Engineering Steam Division, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania*

# Gas turbine application, in HPI

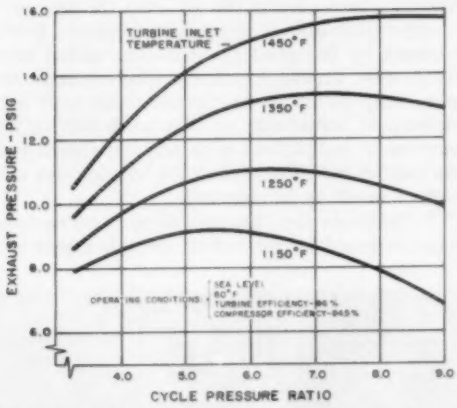


**FIG. 1. Gas turbine gasifier. Exhaust pressure vs cycle pressure ratio with parameters of turbine inlet temperature.**

ECONOMY of installation and competitive operating costs for gas turbine power plants have established an important position for them in the hydrocarbon process industries. The large amounts of thermal energy delivered in the exhaust at usable temperature, and the ability to use a wide selection of fuel, including the waste gas of some processes, have made them extremely attractive.

They are particularly suited for requirements such as the supply of compressed air, hot gases, and mechanical power, or various combinations of these requirements. To simplify discussion, these applications are divided into four major categories:

- Gasifier
- Integrated pressurized process
- Extraction
- Generator or mechanical drives

## Gas turbine gasifiers

The gas turbine gasifier is a machine capable of supplying large amounts of hot exhaust gases at moderate pressure, and varying amounts of mechanical power. A gasifier has been delivered capable of supplying air at 28 psia with a temperature of 1000 F. The gas turbine gasifier is particularly useful with those processes that require hot gas with a large amount of the air's oxygen still unused. Its configuration usually consists of a single-shaft gas turbine that has been modified to provide for a pressurized exhaust. In addition, the turbine component is arranged to develop the work required to drive its air compressor. The balance of the energy input is delivered to the process in the form of pressurized high-temperature exhaust gas. Depending upon circumstances, this machine can be arranged to deliver shaft power, be self-sustaining, or to require boost power. This is determined by such factors as process back pressure, component efficiencies, and metallurgical considerations.

Fig. 1 illustrates the thermodynamic considerations for this type application. Evaluation with the metallurgical attributes regarding permissible operating temperature establishes the limitations of such items as pressure and temperature. Flow, of course, is dependent on frame size.

Fig. 2 is a schematic diagram of the air-and-hot-gas circuit of a butadiene process utilizing two gas turbines as gasifiers. The air compressor takes suction from the atmosphere, and a standard combustor configuration is used to heat its discharge to that temperature required for the turbine portion to supply mechanical energy equal to that absorbed by the compressor. This temperature, of course, is influenced by the back pressure imposed by the resistance of the process.

Fig. 3 illustrates the characteristics of the machines supplied for this application. The catalyst bed is located in the exhaust line, and the gasifier is required to deliver its exhaust at a pressure sufficient to overcome the resistance of the fixed bed, associated piping, and any attached heat-recovery apparatus. The cycle illustrated is one in which the components have been so arranged as to provide a self-sustaining machine. The fuel flow is adjusted automatically by a governor to maintain gasifier speed.

**The process** is endothermic, and requires periodic heating and regeneration of the catalyst bed. Air must be delivered to the catalyst bed in excess of 1000 F. The application is particularly interesting from a thermodynamic standpoint as regards the fuel expenditure required. The heat energy required for a given air-temperature rise above atmospheric conditions is independent of the path followed on a temperature-entropy diagram. Therefore the fuel energy can be determined from the following:

Fuel energy, Btu per lb of air $= 1h_a = C_p\,(t_2 - t_1)$

A gas temperature of 1100 F to the process will require 255 Btu per lb of air delivered. This amount is required regardless of the back pressure. Therefore at lower back pressures the process combustor would be required to burn additional fuel, as the discharge temperature of the gasifier's turbine decreases with a decrease in back pressure. However, the total fuel required will remain the same, whether it be burned in the combustor of the gasifier, or in the process combustor.

Fig. 4 illustrates two gasifier machines in actual operation at a large Southwestern Butadiene installation. The exhausts of these machines are manifolded without the use of isolation or check valves. Starting power is supplied by steam turbines which are connected by an air clutch. These machines have been arranged for single or parallel operation and have been onstream since March 1957.

The control of these machines was arranged in such a manner that with two-unit operation the units start simultaneously, and the governor of the machines is interlocked to keep shaft speeds within a small increment. Shutdown protection is provided in the event of large shaft speed variation. Single-unit operation is obtained by blanking off the discharge flange of the unit not in operation. Shutdown of both units is of course required to change from single to two-unit or from two-unit to single-unit operation. The reliability and availability of the machine has been such that justification does not exist as regards providing the isolation and bleed valve to enable automatic changeover from two-unit or single-unit operation.

**Other methods** of supplying hot gases are available, such as a separately driven compressor with a combustor to raise the temperature to that required by the process. An examination of the thermodynamic characteristics of this method results in the following comparison on a basis of process pressure requirements:

1. Assume radiation and other losses are small and can be neglected.
2. Required air temperature to process — 1100 F.
3. $C_p$ air assumed — 0.25 Btu per lb, K = 1.4.
4. Adiabatic efficiency of separately driven compressor — = 75%.
5. Over-all thermodynamic efficiency of compressor drive — = 25%.

Fig. 5 illustrates that this method requires a fuel energy per lb of gas = 255 + 110.5 = 365.5 Btu per lb of gas.

The ratio of the fuel required by two configurations for the condition cited is 1.43; or the separately driven compressor configuration requires 43% more fuel per lb of air delivered to the process. This would amount to a fuel cost saving of $230,000 per year using a gas turbine gasifier for a process requiring 240 lb of air per sec with a fuel cost of 30 cents per million Btu.

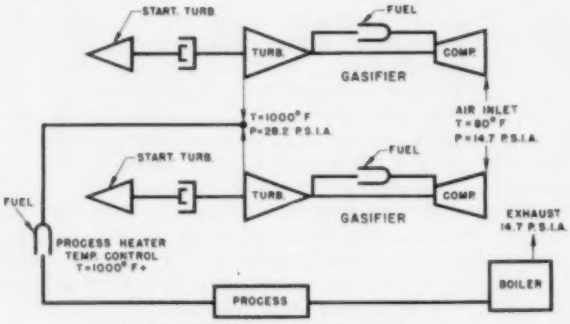


FIG. 2. Gas turbine gasifier application utilizing two machines with common discharge.

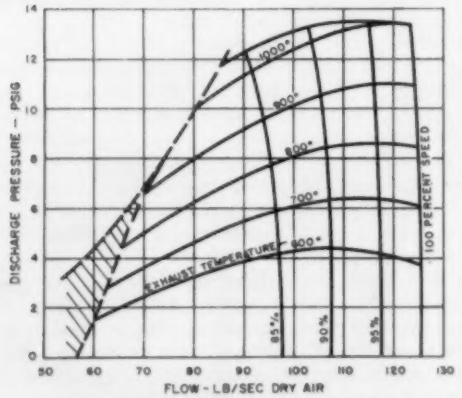


FIG. 3. Gas turbine gasifier discharge pressure and flow characteristics.

These are the advantages of the gas turbines' rejection of heat in usable form. In those cases where the exhaust pressure required is low, the full capability of the power plant can be utilized by arranging it to produce mechanical power as well as hot exhaust gas.

### Gas turbine integrated pressurized process

The integrated pressurized process application of a gas turbine is a method of supplying large air requirements to a process at a pressure level of 3 to 8 atmospheres and higher with the production of varying amounts of power according to the system arrangement and pressure drops. An application of this type is illustrated by Fig. 6.

The compressor takes suction from the atmosphere and delivers the air at the required pressure. In this type of installation an intercooler between compressor casings would normally be used for pressure ratios in excess of 6:1. The discharge of the compressor is routed through the process and then to the turbine. Most of the applications examined to date discharge the air from the process at elevated temperature and at appreciable pressure levels. The fuel required by the gas turbine can be added before or after the process, depending upon process requirements. The maximum temperature to the turbine component is limited by metallurgical considerations. The work balance between the compressor and turbine is largely dependent upon the pressure loss of the process, and the balance can either be absorbed or made up as required.

Fig. 7 illustrates the thermodynamic and metallurgical limitations imposed by gas turbine considerations for these

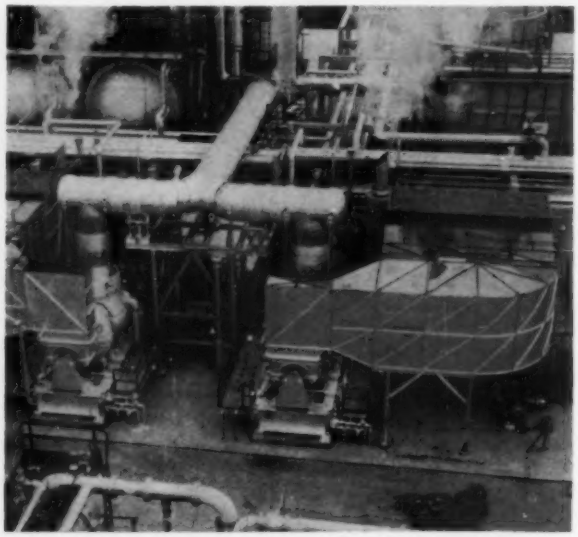

FIG. 4. Two gasifiers in operation at a butadiene plant in the southwest.

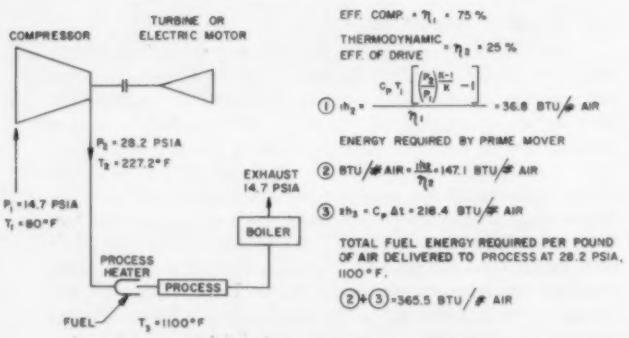
COMPRESSOR
TURBINE OR
ELECTRIC MOTOR
EFF. COMP. = η_c = 75 %
THERMODYNAMIC
EFF. OF DRIVE = η_d = 25 %
① Δh_d = [C_p T_1 ((P_2/P_1)^((K-1)/K) - 1)] / η_c = 36.8 BTU/# AIR
ENERGY REQUIRED BY PRIME MOVER
② BTU/# AIR = Δh_d / η_d = 147.1 BTU/# AIR
③ Δh_3 = C_p Δt = 218.4 BTU/# AIR
TOTAL FUEL ENERGY REQUIRED PER POUND OF AIR DELIVERED TO PROCESS AT 28.2 PSIA, 1100° F.
②+③ = 365.5 BTU/# AIR
P_2 = 28.2 PSIA
T_2 = 227.2° F
EXHAUST
14.7 PSIA
P_1 = 14.7 PSIA
T_1 = 80° F
BOILER
PROCESS
HEATER
PROCESS
FUEL
T_3 = 1100° F

FIG. 5. Hot gas supply to process with separately driven compressor.

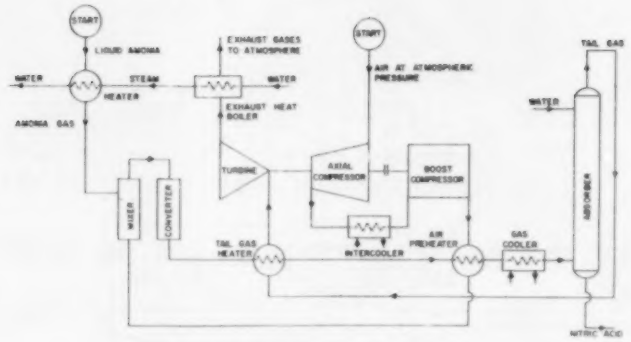


FIG. 6. Schematic diagram of nitric acid process using a gas turbine.

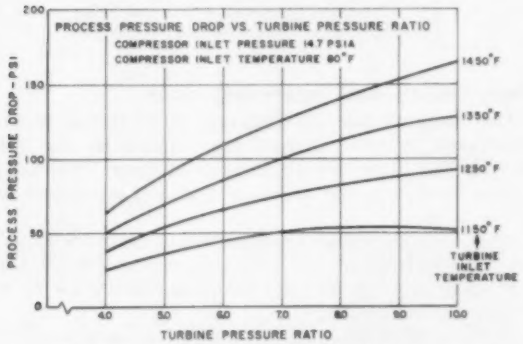


FIG. 7. Process pressure drop vs turbine pressure ratio in gas turbine integrated pressurized process.

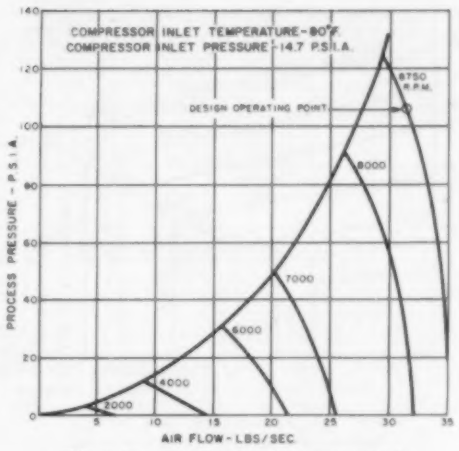


FIG. 8. Integrated gas turbine pressurized process performance characteristics.

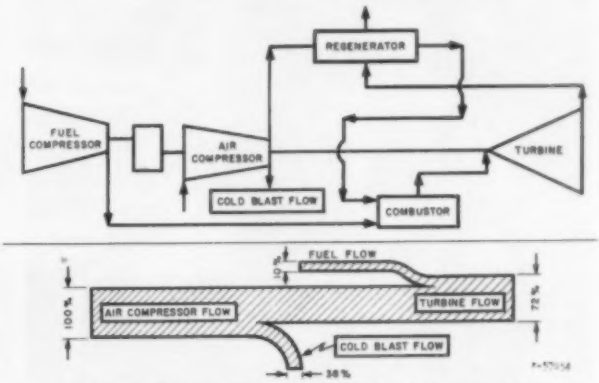


FIG. 9. Regenerative cycle of single-shaft gas turbine used as a 125,000 cu ft per min blast furnace blower.

types of applications. Assuming that the chemical characteristics of any carry-over is not detrimental to the gas turbine, the allowable dust loading for this type of installation should not exceed 0.01 grains per cu ft. Particle size limitations should be set at 95% less than 20 microns, with the maximum not to exceed 100 microns. This will minimize erosion attack. Larger or heavier load can be tolerated, but would most likely result in a maintenance item of turbine blade replacement.

Fig. 8 illustrates the integrated gas turbine pressurized process performance characteristics realized in the application made with a rather small gas turbine in the manufacture of nitric acid at the **Allied Chemical and Dye Plant** at Hopewell, Virginia.

In this installation the gas turbine is started by means of a steam turbine. The discharge of the gas turbine compressor is passed through an intercooler, and then compressed to 120 psia and delivered to the process at a temperature of 450 F. The discharge of the process is heated to 1250 F in a catalytic combustor, passed through the turbine, and routed to a waste-heat boiler. The arrangement once started is self-sustaining. The air flow to the process itself can be varied approximately 30% by means of speed control of the gas turbine set.

### Gas turbine extraction unit

Many processes require the delivery of large amounts of compressed air at pressure levels of 15 to 40 psig which for various reasons are not directly returnable to the gas turbine cycle. This has led to the development of an extraction-type gas turbine that has a stable pressure-flow characteristic from zero to maximum flow.

One application now in operation by United States Steel Corporation (Fig. 9) is used for blast-furnace blowing. Suction for the air compressor is taken from outside the blower building. The discharge flow of the compressor is split so that approximately one third is available to the process, and the balance is routed through a regenerator where it is heated by the exhaust gas. The hot air is then returned to a single external combustor which is fired with blast-furnace gas. This gas is taken from a supply main at a pressure of 8 ounces psig and compressed to combustor pressure by a direct-driven axial-flow compressor. The combustor discharge is then passed through the turbine, the exhaust from the turbine is then passed through the regenerator, and then to the atmosphere.

The gas turbine is cranked by a steam turbine, and assisted to approximately 2000 rpm. It is self-sustaining once started and uses blast-furnace gas as its primary fuel. The secondary emergency stand-by fuel is distillate oil.

Fig. 10 illustrates the performance characteristics of this machine. The cycle characteristics indicate that the machine is flexible and easy to control. Air is available to the process from 0 to 100% flow and at any pressure below the maximum speed parameter.

### Gas turbine power generation

The fourth major category of applying gas turbines within the process industries is the development of mechanical power for direct drives, or the generation of electrical power. This offers an extended field as regards the application of gas turbines because of the requirements of appreciable blocks of power for mechanical drives requiring some speed range.

The gas turbines' ability to utilize the waste gases of different processes as fuel, coupled with a process heat balance that can use the exhaust energy of the gas turbine, is of great interest and importance as regards a process study to

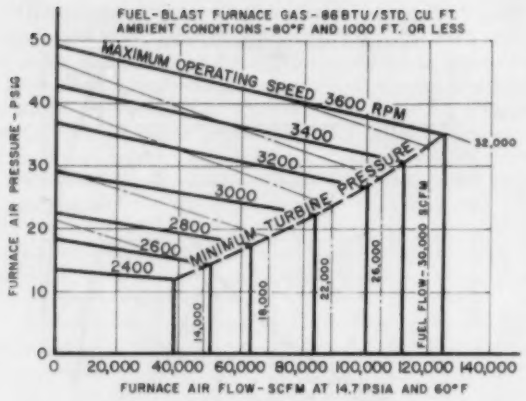


FIG. 10. Performance field of gas turbine used for blast-furnace blowing.

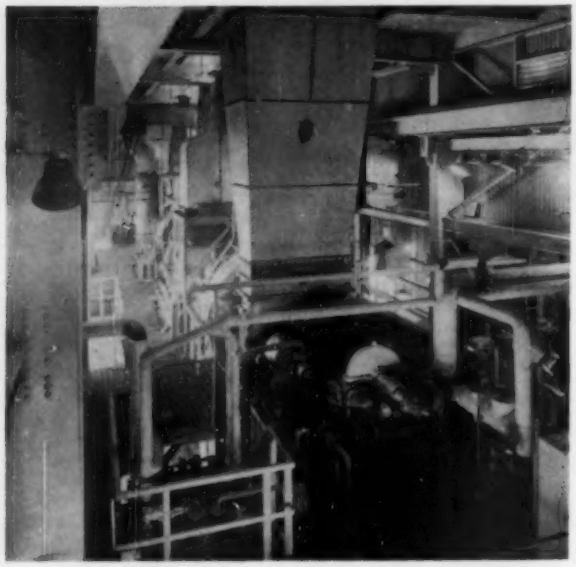

FIG. 11. Two gas turbines used as drives for the air blowing of a catalytic cracking unit at a Southwestern Refinery.

determine equipment selection. The exhaust gases of the gas turbine contain approximately 80% of the oxygen of the intake air, and can therefore be used as preheated combustion air for a boiler, or as the energy supply for a process heat exchanger.

The feasibility of an application can be determined by heat balance, and depends in a great degree upon the commercial availability of a gas turbine having suitable performance characteristics.

Fig. 11 is a site photograph of two gas turbines used as drives for the air blowing of a catalytic refinery unit in the southwest. The exhaust of these machines are used to supply the preheated combustion air to two CO (carbon monoxide) boilers. A schematic of the gas turbine and boiler air circuit is illustrated by Fig. 12.

**Table 1. Cost of First Overhaul (3 Units).**

| Item | Cost | $/KWH Generated |
|---|---|---|
| Labor and Transportation | $12,788 | .00014 |
| Service Engineer | 7,582 | .00008 |
| Materials | 3,104 | .00003 |
| Machine Shop Charges | 2,182 | .00002 |
| Overhead and Incidentals | 2,215 | .00002 |
| Total | $27,871 | .00030 |

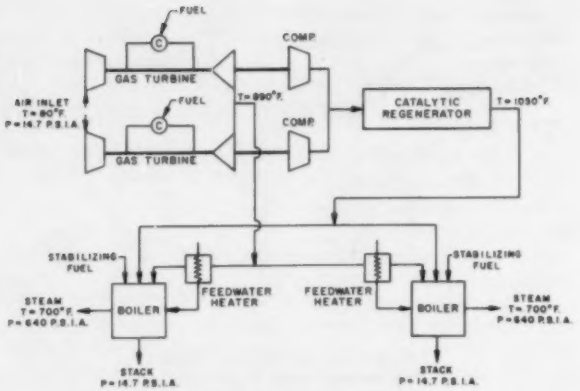


FIG. 12. Schematic of gas turbine and boiler air circuit application shown in Fig. 11.

## Maintenance and operating costs

The Mene Grande Oil Company electrification program undertaken in 1952 utilized gas turbines as the prime movers. The initial plant consisted of three 5000 kw gas turbine-generators and has since been expanded to a total of five units.

The itemized expense incurred during the overhaul of the first three turbines in early 1957 is shown by Table 1. Gross generation up to that time totaled 92,229,100 kw hr with 36,011 machine hours.

The cost of renewal parts for all machines to June 1959 is illustrated by Table 2 (a total installed period of 14 machine years).

Plant operation costs for the year 1958 are illustrated by Table 3.

**Potential applications** for gas turbines exist in various HPI installations. The decision as to which is better, a gas turbine or some other equipment that can accomplish the required function, rests solely with such economic considerations as comparative effects in pay-out periods, operating costs, and potential savings. Many current evaluations and applications in industry for both mechanical drive and power generation are showing a reduced installed cost as well as an improvement in over-all operating economics.

The major concern of many users for the maintenance required of the high temperature parts is fast diminishing. Ten years of continuous operation has demonstrated that a favorable maintenance history can be obtained.

**Table 2. Major Turbine and Generator Repair Parts Used to Date.**

| No. | Item | Unit Cost | Total Cost |
|---|---|---|---|
| 12 | Combustor Basket | $1,077.57 | $12,930.84 |
| 2 | Transition Piece | 1,267.11 | 2,534.22 |
| 0 | Exhaust Bearing | | |
| 1 | Compressor Bearing | 538.20 | 538.20 |
| 2 Set | Pinion Bearings | 737.10 | 1,474.20 |
| 1 Set | Exhaust Turning Vanes | 500.00* | 500.00 |
| 1 | Taylor Transmitter | 549.90 | 549.90 |
| 1 | Hagan Thermostat | 643.50 | 643.50 |
| *Estimated | | Total | $19,170.86 |

**Table 3. Plant Operating Expenses 1958, Gross Generation 84,050,000 kwh.**

| Item | Amount | Cost $/kwh |
|---|---|---|
| Labor and Transportation | 97,934 | .00116 |
| Fuel Gas | 212,519 | .00253 |
| Maintenance Materials and Labor | 52,616 | .00063 |
| Overhead | 5,565 | .00007 |
| Depreciation | 323,698 | .00385 |
| Total | 692,332 | .00824 |

*For the Hydrocarbon Process Industry . .*

# How to specify gas fired turbines

A NEMA* specification exists for gas turbines, but is primarily for the power industry . . . being limited mainly to definition of terms. The absence of any recognized code or standard covering the specification and installation of gas fired turbines for HPI makes it imperative that the design engineer take a careful look at his requirements in order to specify properly. Here is a paper discussing important features for gas turbine installations and offering a suggested form for recording design requirements.

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GAS TURBINES are similar to other equipment items in that the application must fit the job requirements, both mechanically and economically. This applicability to the job is the first factor that must be determined. In this regard, turbines are used to drive pumps and compressors, to generate electrical power, and to provide large volumes of heated air for process uses. The method of applying the turbine power depends upon various factors — safety, operating ease and reliability, physical location and layout — all of which contribute to the final determinant — the economic feasibility. Thus, the manner in which the turbine is to be used must be established before any involved specifications need to be considered.

Turbines may be built to operate on many and varied cycles, involving regeneration, intercooling, and reheating; however, in the sizes we are considering in this instance (under 3000 hp) the added cost at the present for any cycle other than the simple cycle cannot be economically justified by the improved fuel economy, unless fuel costs are high. Therefore, we will consider only the simple-cycle-single-shaft or two-shaft machine.

### Single-shaft or two-shaft

In a single-shaft machine the turbine stages are connected directly to the axial flow compressor and the output shaft. The two-shaft machine is split at the turbine stages with the high pressure turbine driving the axial-flow compressor and the low pressure turbine driving the load. Single shaft units usually are lower in cost, smaller in physical size, simpler to govern but require more starting power, have a lower thermal efficiency at partial load and have a narrow speed variation range without a large loss of power. The operating characteristics of the driven load must be considered with the turbine performance characteristics in order to arrive at a choice.

### Fuels

The gas turbine has a wide range of usefulness so far as fuels are concerned. Gaseous fuels, distillate oils, and heavy residual oils can be used. If gas is used, it must be furnished at a minimum pressure of 150 psig. Natural gas is usually the most desirable fuel when it is available. Distillate oils require storage vessels, pumps and related piping. Residual oils may require expensive treating equipment before they can be safely used.

### Operating conditions

Gas turbine performance is directly effected by atmospheric temperature, altitude, inlet air duct pressure drop and exhaust duct pressure drop.

Fig. 1 is a plot of inlet air temperature versus percent of rated horsepower at various altitudes. *This is not a plot for a particular machine but is included only to indicate these effects.* The altitude correction would be the same year round; however, the difference in seasonal inlet air temperatures can be a significant factor in sizing. If proposed load is greater in winter than summer, the power available and the thermal efficiency should be considered at the lower ambient conditions.

The power loss at higher ambient temperatures can be partially offset by

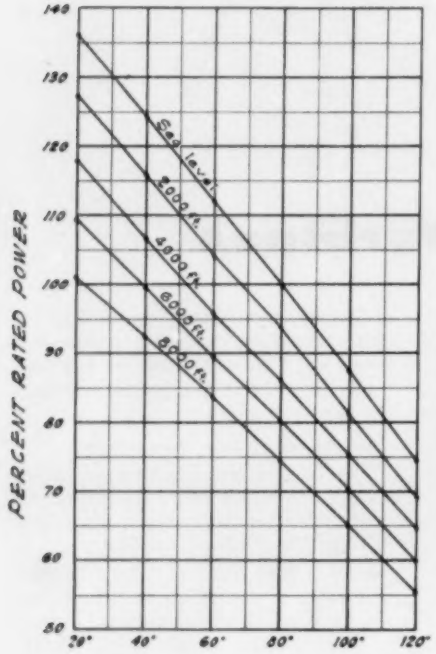


FIG. 1. How inlet air temperature and altitude affect rated turbine horsepower.

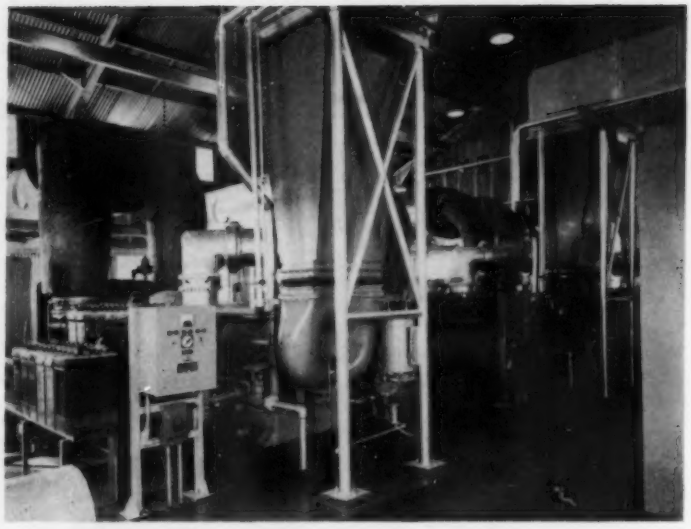

FIG. 2. Three 1150-hp turbines as seen from the inlet end. The inlet air ducts come in overhead from outside the building. The exhaust may be seen in the background.

the use of evaporative coolers to cool the inlet air. Care must be exercised that water is not carried over else decreased power and increased maintenance will result from depositions on the compressor.

The output of a turbine is a function of the pressure ratio across the turbine as well as the mass flow. A pressure drop in the exhaust duct means a decrease in pressure ratio but has no affect on the mass flow of air. But a pressure drop in the inlet duct system means a decrease in pressure ratio and a decrease in mass flow. Thus the pressure drop in the inlet system is much more important to design and rating than in the exhaust system. The design of the exhaust system will also carry through to any heat recovery facilities on the exhaust side of the turbine.

Duct sizing is thus an economic consideration balancing the loss of power due to pressure drop against the cost of increased duct sizes. The ducts must also be structurally designed so that vibration or pulsing of the duct walls will not result from the air flow. The ducts must be supported so that the turbine alignment is not distorted by the weight of the ducts. Fig. 2 is a picture of the air inlet end of three 1150-hp turbines. The exhaust ducts can be seen in the back. Fig. 3 shows the opposite end of the same machines. Note the support structures for the ducts.

An opening such as a handhole, should be provided in the inlet duct to allow the introduction of solid abrasive type cleaners. These cleaners can be used during normal operation for removing any build-up on the axial compressor. Expansion joints are required on both the inlet and exhaust ducts because of the turbine movement due to temperature changes. The duct materials for the exhaust duct must be selected for the temperature service.

Insulation will be required on the discharge duct when heat recovery facilities are included. This insulation can be applied inside or outside; however, an inside application may require a sheet metal jacket to prevent "sloughing off" of the insulation. The big advantage of insulating inside is that the outer duct can then be mild steel with no problems of high temperature.

### Heat recovery systems

Since the thermal efficiency of the gas turbine is lower than conventional reciprocating prime movers, heat recovery to boost this thermal efficiency usually becomes a matter of prime importance, and may be included in the specifications depending upon the proposed extent of the specifications. In fact, as previously mentioned, a gas turbine must be thoroughly engineered in each application. Its use is a matter of economics. The turbine exhaust gas contains approximately 16% oxygen and does not contain any combustibles. The temperature will usually be in the area of 850F for design purposes. Any recovery of the heat energy in this gas stream will increase the turbine thermal efficiency by that amount.

Many schemes for recovering exhaust heat have been proposed or used. These may be simple heat exchangers to produce preheated water or steam, to preheat the turbine inlet air or to exchange heat with any available process steam. More involved facilities may be designed to use the turbine exhaust gas as preheated combustion air and refire this air with additional fuel gas. The design of this type system then approximates a conventional heater or boiler, with the added complications of the necessary ducting to handle the turbine exhaust gas as well as any controls in this gas stream.

A very important consideration arises here. The possible and probable actual operating conditions must be carefully analyzed in the design of the heat recovery facilities. For instance, the gas turbine exhaust temperature may be designed for 850F at sea level and 80F ambient, and at 100% load. Should the load requirement be less than 100%, this can mean that the exhaust gas temperature from the turbine would be less than 850F with a corresponding decrease in the performance of heat recovery facilities. The same situation can occur when the ambient temperature is less than design, in this case 80F. The lower inlet temperature means that more power is available

from the turbine. Should the load remain constant the exhaust temperature will again be lower with the same results. Therefore, the specifications must include not only the probable optimum operating conditions but also the possible variations for proper application.

### Filters

Inlet air filters may be of two types —wet or dry. The wet type is a moving metal curtain that is cleaned by passing through an oil reservoir. The dry type usually is a glass fiber or paper type, either fixed or moving. The dry type may be a mechanical or cyclone type. Both types of filters are sometimes recommended for series operation with the dry filter used to stop any liquid carryover from the wet filter. This dual filter installation should be necessary only in special cases where evidence of excessive fouling of the axial compressor is found.

The filter must be protected against extremes of weather or surrounding conditions. A shroud may be required to prevent sleet, snow, sand or dust from blowing directly into the filter. The necessity for this item will be determined by local conditions.

### Silencers

Silencers for the inlet and exhaust of gas turbine in the sizes considered here are almost standard items. With a heat recovery system, the need for an exhaust silencer is practically eliminated except for extremely critical areas of sound levels. The inlet silencer is made a part of the inlet air ducting and care must be exercised in the selection so that the pressure drop is within allowable limits.

### Starting

As in conventional internal combustion engines, the gas turbine must be cranked to provide sufficient air for combustion. The starting system used may be any of several types—steam turbine, a-c electric motor, d-c electric motor, internal combustion engine or gas expander turbine. The choice of starter will be dependent upon several factors—the driven load, the ability to start at no load or full load, the availability of steam and electric power and the type of starting operation desired . . . manual, semi-automatic, or fully automatic. For instance, a turbine driving a generator with no other source of electric power and with steam or gas not available would require an internal combustion engine or a d-c battery operated motor starter. Also the way the turbine fits into the operating scheme may be a big determinant. The turbine driving a load that can be started after other operating areas of the installation are on the line allows a wider choice of starting systems than the turbine that must be the first piece of equipment put on the line.

Care must be taken to insure that the starting system is large enough to handle not only the turbine but also any of the driven load that cannot be disengaged for start-up.

Should a d-c motor be desired for starting power, the type of electrical system to supply this power must be specified. Storage batteries are available in all qualities and price ranges. The probable operating characteristics must be considered to arrive at the most economical and reliable battery set up. A battery system should include the necessary recharging equipment, including a small engine driven generator should no other source of power be available. The proper selection of batteries and charging equipment can eliminate a potentially large maintenance problem.

### Controls

The designer must decide first on the type of operation—manual, semi-automatic, automatic, or remote. The manual control means that the operator switches on the auxiliaries, then starts cranking the turbine. He adjusts the fuel, ignition, firing speed and the acceleration of the cranking device in bringing the turbine up to speed. In the semi-automatic system, the operator starts the auxiliaries and begins cranking the turbine. The remainder of the starting cycle is automatic. In an automatic system, the operator energizes a control switch which then automatically begins the starting sequence outlined previously. The remote control system means that the automatic control switch is energized from a separate location.

Fig. 4 shows a control panel on three turbines driving generators. The control panel is supplied with the turbine unit and usually very little of the equipment mounted within is open to change. However, the control system supplied must be checked to assure that its purposes and methods are compatible with the operation of the remainder of the installation. The over temperature shutdown control instrument should be investigated in light of the type of turbine loading-constant, variable or highly erratic with extremes of light and full load. A control should be specified that will allow the turbine to operate at or near full load with slight variations in load.

The electrical control system on the turbine must be adequately protected against any radiated heat from the turbine. This may not always allow the shortest possible circuits.

### Auxiliary requirements

The gas turbine requires no cooling water. The only heat load is that picked by up the lubricating oil. This can be removed in an aerial cooler. The cooling of the turbine itself is accomplished by a portion of the air from the axial compressor.

### Construction and fabrication

The turbine should be constructed in components that can be easily handled as units. A horizontally split casing is greatly preferred for ease of inspection and maintenance.

The entire turbine and its accessories should be unitized or skidded as completely as possible. This minimizes foundation and installation requirements. A simple pad type foundation is usually sufficient for such a unit. As previously pointed out, care must be taken to insure that the large inlet and outlet duct systems do not depend on the turbine itself for structural support.

### Guarantees

Any vents, such as from the lubricating oil sump must be located so that the inlet air filter will not pull vapors into the turbine with the resulting fouling of the compressor.

At present, the gas turbine manufacturers offer varied approaches to a user's requirements. Some manufacturers are in a stage of development, others further along. For this reason, it is important that all ratings and data be examined closely to determine that all figures quoted are on the same basis. The fuel rate should be analyzed carefully for the expected operating conditions. Likewise any maintenance figures quoted should also be subjected to close checking. It is possible that some type of maintenance guarantee as well as a fuel rate guarantee should be specified.

**Specifying equipment** is a job that requires experience. Since experience is an item that can be interpreted differently by various people, equipment specifications sometimes vary from person to person and from company to company. A paper which proposes to set out certain hard and fast rules for specifying gas turbines would be useless if the paper attempted to cover

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FIG. 3. The exhaust end of three 1150-hp turbines. These exhaust ducts feed a process heater.

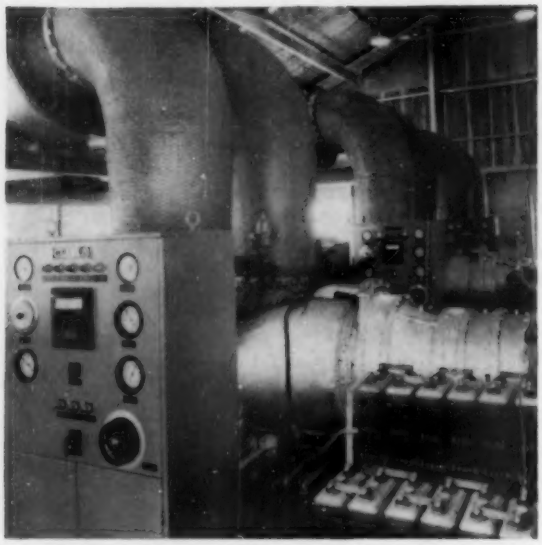


FIG. 4. A control panel for manual starting is shown in the left foreground. Batteries for starting and auxiliary service are to the right.

**DATA SHEET**
**GAS FIRED TURBINES**

DATE_____
Purchaser_____
Location_____ Job. No._____
Item No._____ Service_____ No. Required_____
Driven Equipment_____ Speed_____

**Operating Conditions**

SHP: Rated_____ Normal_____ Max._____ Min._____
Altitude_____
Fuel Available_____ Standby Fuel_____
Fuel Pressure_____
Cooling Water_____ GPM Aerial Cooler_____
Ambient Air Temperature: Max._____ Min._____ Design_____
Allowable Pressure Drop: Inlet Duct_____ Outlet Duct_____
Evaporative Cooling on Inlet_____ Avg. Wet Bulb Temp._____
Exhaust Gas Use_____
Installation: Indoor_____ Outdoor_____ Shed_____

**Accessories**

Air Filter_____
Shroud Required_____ Heater Required_____
Silencer: Inlet_____ Exhaust_____
Starter_____
Starting Load: Turbine Only_____ Turbine & Driven Load_____
Storage Batteries Required_____ Type_____
Voltage_____ Disch. to_____ Volts (Starting)_____ Volts (Control)_____
Charger_____ Constant Voltage_____
Time Required to Recharge to Full Voltage_____

**Control**

Control: Manual_____ Semi-Auto._____ Auto._____ Remote_____
Is Load Constant_____ Variable_____
Type Preferred: Elect._____ Pneumatic_____ Comb._____

**Construction**

Single-Shaft_____ Two-Shaft_____
Casing: Horiz. Split_____ Vert. Split_____
Skid Under: Turbine_____ Turbine & Load_____
Oil Cooler: Mounted_____ Separate_____
Surface Painted_____ Rust Preventative_____
Oil Piping Pickled_____ Openings Plugged_____

**Data Required**

Certified Drawings: Foundation_____ Piping_____
Control_____ Lubrication System_____
Operating & Maintenance Manuals_____
Parts Lists_____ Performance Curves_____

**Additional Remarks**

FIG. 5. A suggested turbine specification sheet.

all applications in detail. Therefore, in this paper we have covered in a general manner, gas turbines as used in natural gas and gasoline operations, especially as related to the author's company operations. The turbine sizes are less than 3000 shaft hp. Such coverage may be limiting; however, the applications are similar for other industrial uses in the hydrocarbon industry.

The use to which these specifications can be put will be dependent upon the manner of purchasing the equipment. If the turbine is being purchased directly by the user, most of these specifications could be applied. Some of the specifications, such as the duct sizing and materials, would not concern the turbine manufacturer if he did not furnish the particular items. The manufacturer will still be concerned that such items are adequate so that the performance of the machine will be as predicated. If the turbine is a part of an overall engineering and construction project and is to be supplied by a contractor, the specifications might require slightly different applications. For instance, the choice between single-or two-shaft machines could not be made before the required loading characteristics were determined by the contractor.

Certain specifications as mentioned above have become practically standard with all manufacturers in the sizes covered. However, there is still enough difference in approach to the construction of various turbines and components to warrant a close look at available machines before ruling out any unit on a single specification point.

Fig. 5 is a suggested specification sheet setting out some of the items mentioned above. This is only a guide or check list. Other factors may enter into a particular installation and must be considered. The use of such a list does not relieve the design engineer of his primary responsibility—to see that the equipment to be used will perform the necessary function as required and will do this economically.

*Design for trouble-free*

# gas turbine operation

**ABOUT THE AUTHOR**

Alexander H. Carameros, who now heads the division test engineering group for El Paso Natural Gas Company, helped install and work out "bugs" in the first 28 gas turbines purchased by El Paso from General Electric. Carameros was a test engineer and served in research and development for General Electric before joining El Paso in 1952. He holds a BS in physics from Texas Western College, a BS in electrical engineering from New Mexico State University and also studied aeronautical engineering three years at the University of Texas.

THE ENGINEER designing a gas turbine installation for a petrochemical plant can capitalize on the experience of El Paso Natural Gas Company, which has racked up more than a million fired hours on 32 gas turbines.

Here are some of the factors we would consider, based on our own operational experience, if we had opportunity to call the shots on a new design . . .

## Design considerations

One of the most desirable things about a gas turbine is that it lends itself to automation or minimum number of operating personnel. To be consistent with this idea, **automatic sequencing in starting is considered mandatory.** There is one disadvantage to going to this type of startup in that the newcomer has a hard time getting used to operating this equipment and is readily willing to go back to the manual methods before he has given himself enough time to train himself and work out the bugs of the equipment. This was our immediate reaction when we began operation eight years ago. Today we have no problem with operation or maintenance of this equipment. Once the equipment is on the line automatic operation has proven to be ideal. Our control monitors station discharge pressure and adjusts turbine speeds to give the called for pressures. Rise in pressure cuts back on speed and fall in pressure increases speed. Not too long ago a large reciprocating station in front of a 3-unit turbine station went off line without notice. The turbines slowed down automatically to minimum speed and as the reciprocating station came back on the line the turbines came back up to full speed without any trouble with surge, etc. This all happened in about an hour and the operator did not know it until the emergency was all over. This is a typical example of the excellence of this method control in actual operation.

The customer in the original consideration ordinarily has something to say about the **inlet filter.** This may sound like a simple choice but it should be tempered somewhat with the lessons taught by experience. Our original gas turbine installation had a combination inlet water evaporative cooler and filter. Water carryover soon became a problem and it was reduced by operating the cooler only when the humidity was less than 50%. The filter operated more efficiently when the pads were wet. During the winter time operation it was necessary to turn off the water to the cooling pads when ambient temperature dropped to 50 F to prevent freezing. This meant that the filter was operating at less than maximum efficiency, about 40% of the time.

The next time turbines were installed a traveling oil curtain was installed in front of the cooling pads as a primary filter. The only problem encountered here is that the inlet filter tends to freeze over solid during the snow storms. This problem is relieved by opening the doors on the side till the storm is over. Another user was operating turbines in an area where the humidity was above 50% most of the year. He could not utilize the evaporative cooling advantage so he decided to install a fine paper filter and thought that his "dirty compressor" problems were solved. A loss in turbine horsepower showed that the axial flow compressor had been fouled by pollen which would not be stopped by the filter. So it appears that trouble-free operation on the axial flow compressor is impossible by filtering methods.

This leads to another requirement that should be considered and that is any **easy way of cleaning the axial flow compressor under operating conditions.** The users have

FIG. 1. Burned cross-fire tube, probably caused by unbalanced combustion pressures.

FIG. 2. Carbon build-up in cowl cap, probably caused by liquids in fuel and poor clearances.

played around with spent catalyst and water washing of the compressors but the results are not completely satisfactory. Most of the cleaning occurs on the rotor blades and hardly any on the stator blades. This problem needs serious consideration by the manufacturers.

The idea of a **common lube oil system between the compressor and turbine** has been argued enough to permanently establish that it is a good and sound idea. No problem has arisen in operation which can be attributed to the common system. Some slight contamination has been noticed but where sweet gas is pumped no problem should arise.

### Operational feedback

Our operational experience has shown that it is not unreasonable to demand a turbine that will run 30,000 hours between major overhauls. Of course, this should be tempered with good judgment based on **performance testing and 8000 hour combustion inspections.** The main reason for 1-year combustion system inspections is that rarely some liquid may get into the gas or a small metal clip might break, which in turn might cause damage to the combustion system. (See Fig. 1 and 2.)

As the gas turbine goes into operation there invariably are a certain number of things that will have been overlooked in the original consideration. **Instrumentation is ordinarily not adequate for one reason or another.**

An **indication of inlet firing temperature** is ordinarily an important function which is not recorded, and if it is, its absolute accuracy is always in question. The life of the machine and all its components depends largely on this function. Yet, very little proportioned attention is given to this fact.

Another good indication of gas turbine performance lies in the **vibration level** of the machine. Most turbines are operating at speeds of 5000 rpm and greater. Very low amplitudes at these high speeds can damage equipment. Such equipment should be of a **continuous monitoring type and record only on demand.** Once a good vibration instrument is chosen, it is used throughout the installation. Care should be taken when choosing a vibration pickup to monitor the gas compressor vibration. Many times a vibration pickup is installed on the compressor to protect the bearings. On high pressure gas line centrifugal compressors the case will weigh about 30,000 lb or more and the shaft and impellar assembly about 900 lb. It is unlikely that an assembly this small can shake the case enough to monitor it without destroying the bearings. A pickup should be installed that monitors shaft vibration directly. Such an instrument is available if the compressor manufacturers will take notice of Fig. 3.

When the gas turbine is new, and as it gets older the user is constantly faced with the **problem of measuring the output.** An instrument such as torque-meter which could be

FIG. 3. Shaft mounted vibration pickup for use on high pressure centrifugal compressors.

FIG. 4. Load turbine rotor damaged due to thrust bearing failures.

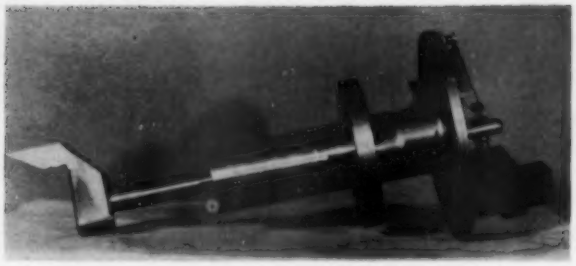


FIG. 5. Thrust bearing trip device will shut down turbine if thrust bearing fails.

placed between the load and turbine would be ideal. This problem at the present time is being studied and evaluated on a joint venture by General Electric Company, Clark Brothers, and Tennessee Gas Pipeline Company.

Last, but not least with respect to instrumentation, a **means of detecting shaft movement** axially and vertically is necessary. Our operation has shown that both journal and thrust bearing failures cannot be detected with vibration pickups or bearing drain thermocouples. The failure of the axial flow compressor thrust bearing could result in a $50,000 failure, and one on the load wheel could cost $30,000, not including downtime or labor. (See Fig. 4.) A small $100 device such as shown in Fig. 5 could prevent such a catastrophic failure.

### Maintenance feedback

A review of the previous material indicates that the greatest need for good turbine operation is in the field of instrumentation. The gas turbine alone is adequate, if some small design considerations could be reviewed. These conditions only become apparent after the user begins to maintain his gas turbine.

It was not long after we received our machines that we began removing all rubber hoses and couplings. This type of material is not consistent with high temperature operation. Soon all rubber hoses and couplings will be entirely replaced on all our turbines. This will be expensive, but it is felt that only by such action can we achieve our goal of 30,000 hours between major overhauls.

Another feature which should be noted especially in the design of the accessories is to eliminate high speed, ball bearings. Our inability to predict accurately the life of high speed ball bearings has led us again to eliminate them from our operations.

The use or maybe the improper use of "O" rings on our turbines has given us a considerable amount of trouble. Their discontinuance is being pushed daily especially where the seal is moving. Again, our main object is long life, with minimum maintenance.

A chronic complaint that continually comes in from the field is "Why the ---- do we need to have tapped bolt holes in high temperature areas?" Thread seizure in high temperature application has always been a problem regardless of the type of thread compound used. I would like to ask the manufacturers of gas turbines and super chargers the same question. It is much easier to cut bolt and nut in two instead of drilling out a bolt from a main frame.

One of the greatest needs now current with the users of gas turbines is for a means of determining the amount of useful life left in certain high temperature components. All these parts are expensive to replace and even more expensive if they should fail. The user would like to know, for example, how many more hours are left in a turbine bucket after 60,000 hours of operation. He may choose to reinstall if it is more than 30,000 hours and replace if it is less than 30,000 hours. (See Fig. 7.)

Fig. 6. Failed high speed ball bearing.

FIG. 7. High pressure turbine bucket failure.

Many of the accessories have often affected the operation of the turbine. Too many times a $25 protective device, when not operating properly, can shut down a $1,000,000 turbine. It should also be pointed out that when the gas turbine is placed on a line, accessibility is often poor. For this reason special attention should be given to making accessories such as fuel governors, valves, etc., as light as possible. It is much easier to replace components in the field and overhaul them at a central location than to try to repair them on the machine while the dispatcher screams for the machine to come back on the line.

### References


1. "Comparison of Operating Characteristics of a Two Shaft Gas Turbine With A Single Shaft Gas Turbine for Gas Line Pumping," by M. J. McDonough ASME Paper No. 60 GTP-17.
2. "Two Shaft or Single Shaft Gas Turbines for Your Compressor Stations," by J. L. Mangan and T. C. Heard, *O.G.J.*, May 23, 1960, page 107.


★ ★ ★

# Intake air system design

AIR TREATMENT is part of the design concept of the large industrial combustion turbine. Silencing, to some degree, is utilized in nearly all installations. Cooling is included occasionally under certain conditions, and the use of filtration — well, this has been a matter of different policy between manufacturers and even of difference of opinion between people of the same organization. Generally, the policy as to whether or not a filter should be included can be expressed in three basic schools of thought. They are:

- Leave it off and see if you can get by without it.
- Put it on when you know there is abrasive dust, making air cleaning a necessity.
- Include filtration as good insurance for protection of an expensive piece of equipment, as its repair, if damaged, would cost more than the filter installation.

The reason for these differences of opinion on the use of filtration as compared with the other components is understandable. With silencing you are dealing with measurable values, even though the phenomenon is intangible. The results of its use are easily and quickly felt and evaluated. With proper information the results can be predetermined and guaranteed. Its measurement and performance are the same yesterday, today, and tomorrow. Its application is a science.

With cooling, again, this is a science, since for a given set of atmospheric

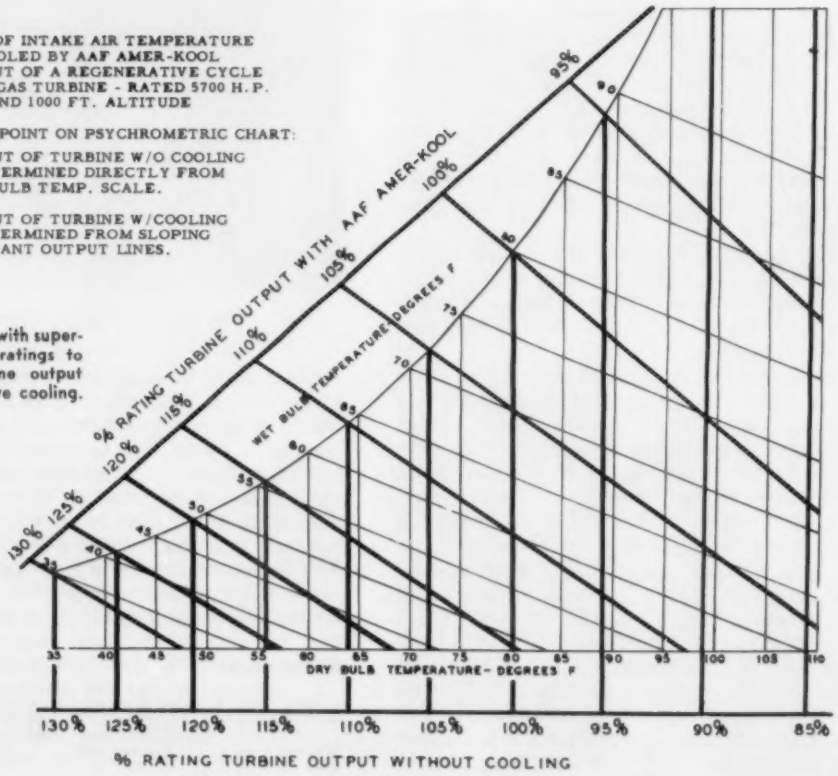

EFFECT OF INTAKE AIR TEMPERATURE WHEN COOLED BY AAF AMER-KOOL ON OUTPUT OF A REGENERATIVE CYCLE 2-SHAFT GAS TURBINE - RATED 5700 H.P. @ 80° F AND 1000 FT. ALTITUDE
FOR ANY POINT ON PSYCHROMETRIC CHART:
1. OUTPUT OF TURBINE W/O COOLING IS DETERMINED DIRECTLY FROM DRY BULB TEMP. SCALE.
2. OUTPUT OF TURBINE W/COOLING IS DETERMINED FROM SLOPING CONSTANT OUTPUT LINES.
% RATING TURBINE OUTPUT WITH AAF AMER-KOOL
WET BULB TEMPERATURE-DEGREES F
DRY BULB TEMPERATURE- DEGREES F
% RATING TURBINE OUTPUT WITHOUT COOLING

FIG. 1. Psychrometric chart with superimposed turbine output ratings to show comparison of turbine output with and without evaporative cooling.

# for gas turbines

**DWIGHT M. McMAKIN,** *American Air Filter Company, Inc.*
*Louisville 8, Kentucky*

conditions its results can be directly expressed in turbine performance. Of course, the atmospheric conditions vary from hour to hour and from day to day, but the performance of the cooler is always approximately the same for the same conditions, and the performance can be pre-determined and easily observed after it has been installed.

### Air filtration

But when it comes to filtration, practically none of these points holds true. It is an accepted fact that the proper application of air filtration is an art and not a science, and experience is one of the big factors in this art. Let us look further at this experience factor. No manufacturer of a reciprocating engine or compressor would consider installing one without a filter. It is a well established fact through years of experience that a filter is required. There is never any question as to the justification of the use of a filter. The only question is the kind and type to give the performance and type of maintenance desired. This is not true for the gas turbine. Today's concept of the industrial gas turbine is relatively young. It has only been commercially significant for some twenty years.

**Dust particles** suspended in air are mostly invisible, having a medium size of 0.6 micron and a range in concentration from 0.05 grains per Mcf in suburban areas to 0.25 grains per Mcf in industrial areas. A dust storm concentration will range 1000 times, more or less, than concentration in normal atmosphere but will also have a larger medium particle size. Most particles are invisible and are only seen by reflected light, like the satellites that have recently been put in orbit. The smallest particle that can be seen by the naked eye under optimum viewing conditions is 10 microns. Therefore, we can easily say the smallest particle most of us actually see is in the 30 or 40 micron range. It is generally accepted by the turbine engineers that particles of 10 microns and above will have a damaging effect on the compressor blades. Not only does the size of this particle affect its ability to do damage, but also its shape, specific gravity, hardness, and surface contour enter into it. These same factors affect the ability of the filter to remove them.

Therefore, with filters you are dealing strictly with intangibles that cannot practically be measured in the field. Their effect cannot readily be observed and evaluated. It is usually expensive and impractical to take exact measurements at any installation to determine all the dust characteristics and concentrations present to provide data on what the filter will be handling. This type of evaluation would take a minimum of one year, since conditions change with the seasons. Therefore, the filter performance at the installation cannot be predicted or truthfully guaranteed. To further complicate the over-all picture, it has never been established just what degree of filtration a turbine requires.

It is easy to understand why different ideas exist as to filtration, for they are based on limited experience and incomplete information. Yet, a decision as to whether or not a filter should be used and the type of filtration most desirable is expected.

For air filters, experience is an important factor in selecting the proper size, type, degree of filtration, and configuration for each application. This experience is made up of the general background of all other installations, how well they are performing, and the limits the location of a particular in-

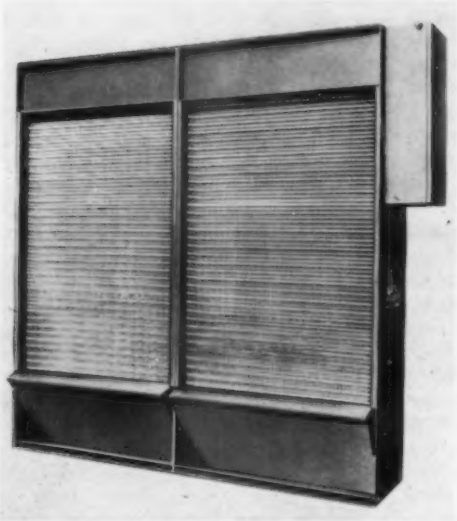


FIG. 2. Double section filter. Any size bank can be built up by placing sections side by side.

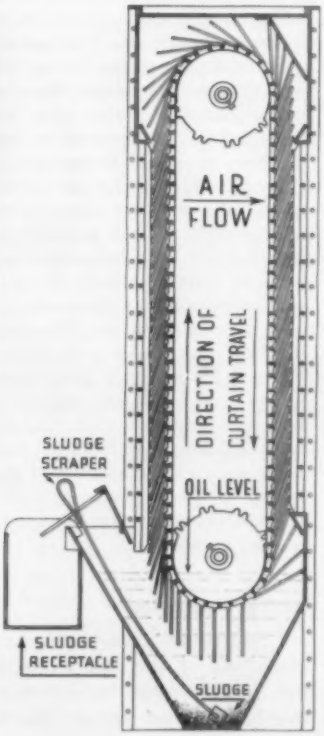



FIG. 3. Sectional view of filter shown in Fig. 2, indicating principle of operation and how washing of panels is assured by their separation in the reservoir.

stallation impose, such as wind direction, nearness of other equipment which may affect operation, and the type of filter which has generally proven most satisfactory in that area for similar applications. The experience of local filter people should be utilized to its maximum advantage. This will assure the most satisfactory filter application with a minimum amount of maintenance and capital investment.

There are certain characteristics of a turbine that affect the selection of components for the air intake system and should, therefore, be pointed out.

The axial flow compressor used in all large industrial turbines is a constant volume machine. Therefore, for a given speed, it always moves the same volume of air, although this air might be at different densities. For this reason, it is simpler to use cubic feet per minute as the unit of volume rather than pounds per second when working with the intake system of air. The conversion from pounds to cubic feet is made at the turbine rating condition of 80 F and 1000 ft altitude. The conversion figure is 847 cu ft per min per lb per sec of intake air. The volume determined at this 80 F and 1000 ft altitude never changes within the intake system regardless of changes in ambient temperature or altitude, unless it is changed by passing through a cooler. Therefore, the sizing air volume for selection of air conditioning components does not change with variation in installation design temperature and altitude.

### Air cooling

Due to its design the turbine output is affected by the temperature of air entering the compressor. When the temperature goes above 80 deg, there is a loss of horsepower. Correspondingly, when the temperature goes below 80 deg, there is a gain above rated horsepower. A 40 F change in temperature will result in approximately a 25% change in output horsepower. The evaporative cooler is quite effective in reducing temperatures within the intake system and thereby increases the turbine output over that obtainable at ambient temperatures. It is particularly beneficial in meeting horsepower demands during the heat of the day and seasons of the year when the temperature goes above this 80 deg rating. Evaporative coolers on turbine applications do not share the same limitations as to high relative humidity as they do when used for comfort cooling, for on turbines its main object is usually to prevent intake air temperatures from going above 80 F. This is practical any place in the United States, as the spread between wet and dry bulb temperatures is always enough to provide sufficient cooling. Also, as the dry bulb temperature rises in the middle of the day this spread generally increases, giving the maximum potential cooling during that part of the day when it is most needed.

For an illustration of the effect of temperature on turbine output, refer to Fig. 1 which is a basic psychrometric chart with turbine output ratings superimposed on it. It gives a ready comparison of turbine output with and without evaporative cooling. If ambient temperatures are 99 F dry bulb and 75 F wet bulb, the turbine will deliver only 90% of its rated capacity without cooling. With an evaporative cooler operating at the same temperatures, the output would be 100% of rating. Similar comparisons can be made at any other operating condition.

It was not until the refinement of axial flow compressors reached their present degree of efficiency that t he modern gas turbine became practical. It requires approximately 80% efficiency from this compressor to sustain operation of the turbine. Maximum compressor efficiency is in the order of 86%. It is, therefore, imperative to keep the compressor operation at peak performance, for as its efficiency decreases, the turbine output horsepower decreases but the fuel consumption rate stays the same. Whenever the compressor efficiency drops to a point where it is no longer economical to operate the turbine, it has to be shut down for maintenance or overhaul.

One of the most important factors in the intake system of a gas turbine is the resistance to air flow or pressure loss. This is understandable when we realize that 4-in. water gage pressure loss in the intake system is equal to 2% loss of output horsepower, while it is only 1% loss for the same 4-in. water gage pressure drop in the exhaust system. This is probably one of the reasons it is so interesting to eliminate air conditioning components whenever possible without bringing on more serious problems. The resistance of filter and cooler will range from 0.5 to 1.25-in. water gage depending on the kind used and whether or not they are used in series. The silencer would likewise vary from 0.5 to 1.0-in. water gage. Most often it is the duct system outside the air-conditioning components which add the most resistance to air flow.

### Noise reduction

Low-frequency noise from rotating machinery of this size is self-evident and to this rumble the turbine adds its own high-pitched scream. This noise is a high-frequency whine caused by the cutoff frequency of rotating blades spinning or moving past the stationary blades at the close tolerances required to make the compressor operate. In most industrial applications, it is this high-frequency whine that is the controlling factor for noise control. Its power has to be reduced to a sound pressure level, measured in decibels at a given distance from the noise source, that operating personnel can stand without damage to their hearing. The sound pressure level a person can stand without damage is much higher for short durations of exposure than for continuous exposure, for an eight-hour shift, day in and day out. Therefore, the maximum sound pressure level allowed at locations throughout any installation will be determined by the maximum time a person is to be exposed to this noise. It then follows that the noise-control requirements established will vary with the over-all design concept of the installation and influenced by such things as whether the turbine is unattended and operated by remote control or whether there will be an operator on duty at all times. If it is to be an attended installation, will the sound pressure level have to be brought down to that which a man could stand continuously, or will a sound-proof control room be utilized?

The control of high-frequency noise is relatively simple when compared with low frequencies and can usually be done in much less space and, therefore, more economically. High-frequency waves travel in straight lines, like light, and require much less mass and space to absorb them. Silencers designed for turbine intakes usually consist of sound-absorbing surfaces placed parallel to the direction of air flow and in sufficient numbers to divide the air stream as often as is practical. Some manufacturers place these paral-

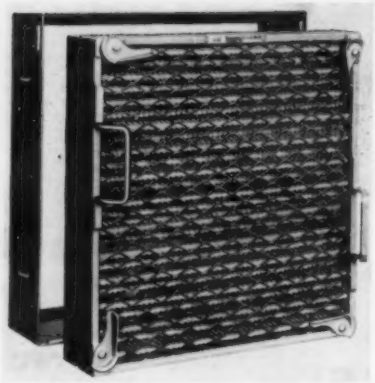


FIG. 4. Permanent washable filter cell, which is assembled in banks to provide adequate capacity.

lel sound-absorbing surfaces in aerodynamic curve patterns so that the sound wave not only moves through sound-absorbing channels but strike sound-absorbing surfaces and, therefore, are not reflected. With these designs, high values of attenuation are obtained in a relatively short space in the octave bands 1200 to 4800 cps where most of the silencing is needed.

After the criteria for acceptable noise of the air intake has been established, fortunately the selection of a silencer is not difficult. The sound power level can generally be gotten from the turbine manufacturer, as this is a measure of the noise spectrum emitted from the source of intake of the compressor. It is then a matter of determining the amount of attenuation needed to reduce this noise in each octave band to the sound pressure level desired at the design distance from the noise source, allowing for the attenuation from dispursion due to this distance. Any reliable silencer manufacturer can then give the size of his unit and its resistance to air flow to meet this desired attenuation.

It should also be pointed out that an intake air filter will extend the life of an inlet silencer by reducing the amount of dirt getting to it and plugging up the perforated holes through which the noise travels to get to the sound-absorbing fluff.

FIG. 5. Front view of roll type filter. The clean roll is inside the cover at the top. Used media is re-wound at the bottom.

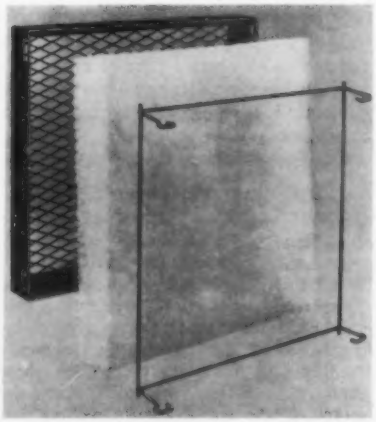


FIG. 6. Filter unit using a disposable glass pad which is replaced by a new pad when serviced.

## Components for specific applications

We have now completed our examination of different compressor characteristics and how they affect or are affected by the components of intake air systems. Let us examine now the individual components and some of their general characteristics.

It is our firm belief that the components when used in combination with each other should be installed in this order: filter, cooler, silencer. The filter should be ahead of the cooler to keep as much dirt out of it as possible, utilizing the filter to its fullest advantage. Dirt in an evaporation cooler seems to encourage salt deposits. It also increases the material accumulating on the recirculating pump intake screens and increases plug of the spray nozzles. If the cooler is placed in front of the filter, the possibility of rust of the filter is increased which sometimes means special materials or protective coatings for certain parts.

The filter that has been in use longest and most often on gas turbine intakes is the automatic, self-cleaning, viscous impingement type which uses oil as the collective adhesive on baffles in the air stream. A typical example of this filter is shown in Fig. 2.

This type filter has adequate cleaning efficiency for most applications and can handle large dust loads with a minimum of maintenance. Its self-cleaning feature makes it most attractive for handling large air volumes, especially for continuous operation. A lot of people have been skeptical about its use on axial flow compressor intakes because of the possibility of oil carryover and the trouble an adhesive can cause on the compressor blades as explained above. The use of this type of filter in many installations has proven, however, that when properly sized and with proper installation and maintenance, there is no need for concern.

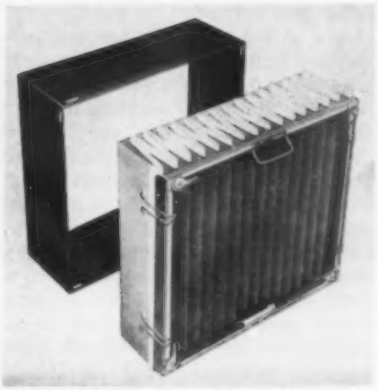


FIG. 7. This type of filter cell can provide a range of clean efficiencies by using different media. A sheet of media is supported in deep pleats to increase the ratio of filtering surface to face area.

The same degree of filter efficiency can be obtained by a bank of manually cleaned permanent cells, but their service is quite laborious due to the number required to handle the air volume requirements. Their use on gas turbines has been restricted to standby power installations where a very inexpensive installation was desirable.

A filter which is growing in popularity in the gas turbine industry is the type shown in Fig. 5. It features a disposable glass mat media in 65-ft long rolls automatically fed into the filter as needed and re-rolled after using. Servicing merely consists of removing the used roll of dirty filter media and replacing it with a clean one. Its main advantage is that, although the principle of operation is viscous impingement, the adhesive is a jelly, so it has a characteristic of a dry filter as far as oil carryover is concerned but still maintains the compactness and ease of maintenance of the viscous impingement type. This type is particularly applicable for materials that are difficult to wash out of a permanent filter such as bugs and linty fibers and for certain types of dirt that will not settle in oil, such as carbon black.

Again, the same degree of efficiency is available in individual pads which are manually removed from the frames and replaced one at a time. Fig. 6 shows an example of this type unit.

The type of filter which was initially used on the first United States turbine installation was the true dry-type filter operating on the seining principle, that is, the particular size that it would stop was determined by the size of the openings in the felt media. These filters are permanent cells with media which is replaceable and so designed to get a large amount of surface in a small

area. This is typified by the filter cell shown in Fig. 7. These are manually serviced units requiring a rather large size installation to get sufficient service life and even then require frequent servicing. Although they are still preferred by some as primary filters, their chief advantage is as a secondary filter where it is desirous to have a higher degree of filtration than is obtained by either of the primary filter types. Also, this type of series installations make their service life acceptable, approximately once a year. Their high degree of filtration has proven advantageous in some industrial installations where there is an abnormal amount of very small dirt particles which adhere to the compressor blades.

There are other cleaning devices which have been used on the intake air to turbines, but since they are of special design, these are not appropriate to this discussion.

A word of caution on the selection of air intake filters for gas turbines. Just because a certain filter falls within a general class as to type and principle of operation does not mean it will be satisfactory for gas turbine use, although others in this same class may have proven so. Each filter has its own operating characteristics and it is probably quite adequate for the service for which it was designed. But that alone does not mean that these same characteristics are all suitable for gas turbine application. Therefore, avoid the hazards of the sloppy specifications we occasionally see such as "a suitable air filter of the rotating screen type," and the troubles to which this approach can lead.

Evaporative coolers of all types have been used on gas turbines with varying degrees of success. Most of them are designed to cool water, and if some water is carried over with the air passing through them, this is immaterial. This is not true for the gas turbine. Any water droplets, no matter how small, carried into the compressor intake will cause trouble. In the first place, they contain salts which will be deposited on the blades when the water evaporates. Secondly, they will serve as an adhesive to collect other submicron particles which are in the air stream and normally would go on through the compressor without being collected. The evaporative cooler is not required in every installation. It is basically a cheap way to buy horsepower by reducing intake air temperatures when full rating of the turbine condition. When an evaporative cooler is installed behind a filter, the air volume used in selecting the filter size should be adjusted for the difference in volume caused by the change in temperature across the cooler. It is possible to get

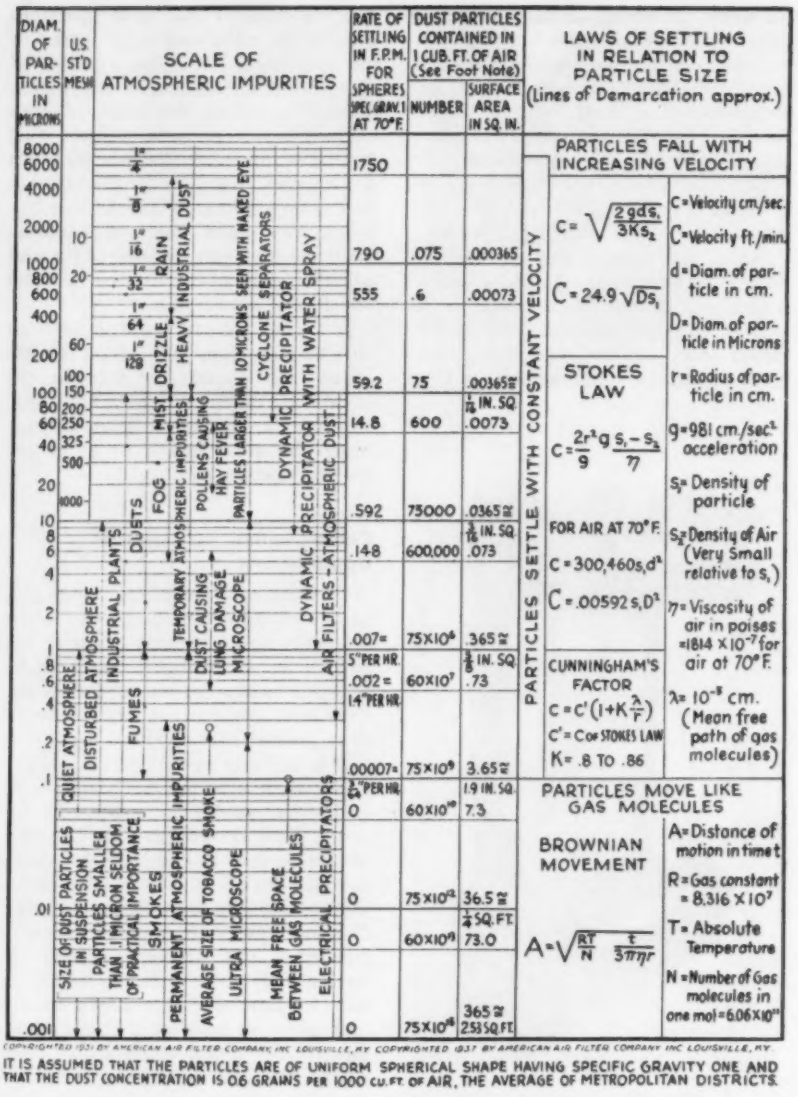

DIAM. OF PARTICLES IN MICRONS
U.S. STD MESH
SCALE OF ATMOSPHERIC IMPURITIES
RATE OF SETTLING IN F.P.M. FOR SPHERES SPEC. GRAV. 1 AT 70°F.
DUST PARTICLES CONTAINED IN 1 CUB. FT. OF AIR (See Foot Note)
NUMBER
SURFACE AREA IN SQ. IN.
LAWS OF SETTLING IN RELATION TO PARTICLE SIZE (Lines of Demarcation approx.)
PARTICLES FALL WITH INCREASING VELOCITY
PARTICLES SETTLE WITH CONSTANT VELOCITY
STOKES LAW
FOR AIR AT 70°F.
CUNNINGHAM'S FACTOR
PARTICLES MOVE LIKE GAS MOLECULES
BROWNIAN MOVEMENT
C = Velocity cm/sec.
C' = Velocity ft./min.
d = Diam. of particle in cm.
D = Diam. of particle in Microns
r = Radius of particle in cm.
g = 981 cm/sec² acceleration
S₁ = Density of particle
S₂ = Density of Air (Very Small relative to S₁)
η = Viscosity of air in poises = 1814 X 10⁻⁷ for air at 70°F.
λ = 10⁻⁵ cm. (Mean free path of gas molecules)
K = .8 TO .86
R = Gas constant = 8.316 X 10⁷
T = Absolute Temperature
N = Number of Gas molecules in one mol = 6.06 X 10²³
1750
790
.075
.000365
555
.6
.00073
59.2
75
.00365 IN. SQ.
14.8
600
1/16 IN. SQ. .0073
.592
75000
.0365 IN. SQ.
.148
600,000
3/16 IN. SQ. .073
.007 =
75X10⁴
.365 IN. SQ.
5" PER HR.
.002 =
60X10⁷
1/8 IN. SQ. .73
14" PER HR.
.00007 =
75X10⁹
3.65 IN. SQ.
1/4" PER HR.
0
60X10¹⁰
1.9 IN. SQ. 7.3
0
75X10¹²
36.5 IN. SQ.
0
60X10⁹
1/4 SQ. FT. 73.0
0
75X10¹⁵
365 IN. SQ. 2.53 SQ. FT.
QUIET ATMOSPHERE
DISTURBED ATMOSPHERE
INDUSTRIAL PLANTS
DUSTS
FOG
MIST
DRIZZLE
RAIN
HEAVY INDUSTRIAL DUST
TEMPORARY ATMOSPHERIC IMPURITIES
POLLENS CAUSING HAY FEVER
DUST CAUSING LUNG DAMAGE
MICROSCOPE
PARTICLES LARGER THAN 10 MICRONS SEEN WITH NAKED EYE
CYCLONE SEPARATORS
DYNAMIC PRECIPITATOR
DYNAMIC PRECIPITATOR WITH WATER SPRAY
AIR FILTERS - ATMOSPHERIC DUST
FUMES
SIZE OF DUST PARTICLES IN SUSPENSION
PARTICLES SMALLER THAN .1 MICRON SELDOM OF PRACTICAL IMPORTANCE
SMOKES
PERMANENT ATMOSPHERIC IMPURITIES
AVERAGE SIZE OF TOBACCO SMOKE
ULTRA MICROSCOPE
MEAN FREE SPACE BETWEEN GAS MOLECULES
ELECTRICAL PRECIPITATORS
COPYRIGHTED 1951 BY AMERICAN AIR FILTER COMPANY, INC. LOUISVILLE, KY. COPYRIGHTED 1937 BY AMERICAN AIR FILTER COMPANY INC. LOUISVILLE, KY.
IT IS ASSUMED THAT THE PARTICLES ARE OF UNIFORM SPHERICAL SHAPE HAVING SPECIFIC GRAVITY ONE AND THAT THE DUST CONCENTRATION IS 0.6 GRAINS PER 1000 CU. FT. OF AIR, THE AVERAGE OF METROPOLITAN DISTRICTS.

FIG. 8. The Frank Chart, showing size and characteristics of air-borne solids, illustrates particle sizes of dust which damages compressor blades.

as much as a 25 to 30 F difference in temperature between entering and leaving air.

From the user's viewpoint, there is a silver lining to this cloud of controversy which hangs over the components of the air intake system. The ideas of the industry are becoming more uniform as to the need and requirements for these components. The user is not put in a quandary as often by the difference of opinion as to what his intake system should include. The experience we have gained over the past 10 to 12 years is beginning to show the need for a device suitable for use on normal industrial atmospheres which not only will provide an adequate degree of dirt removal to prevent blade erosion, but will be compact in size, low in maintenance, acceptable in resistance, simple in operation, mountable on the turbine, provide adequate sound control, and be inexpensive enough to be made a part of every turbine installation. In my opinion, this device is just around the corner. ★ ★

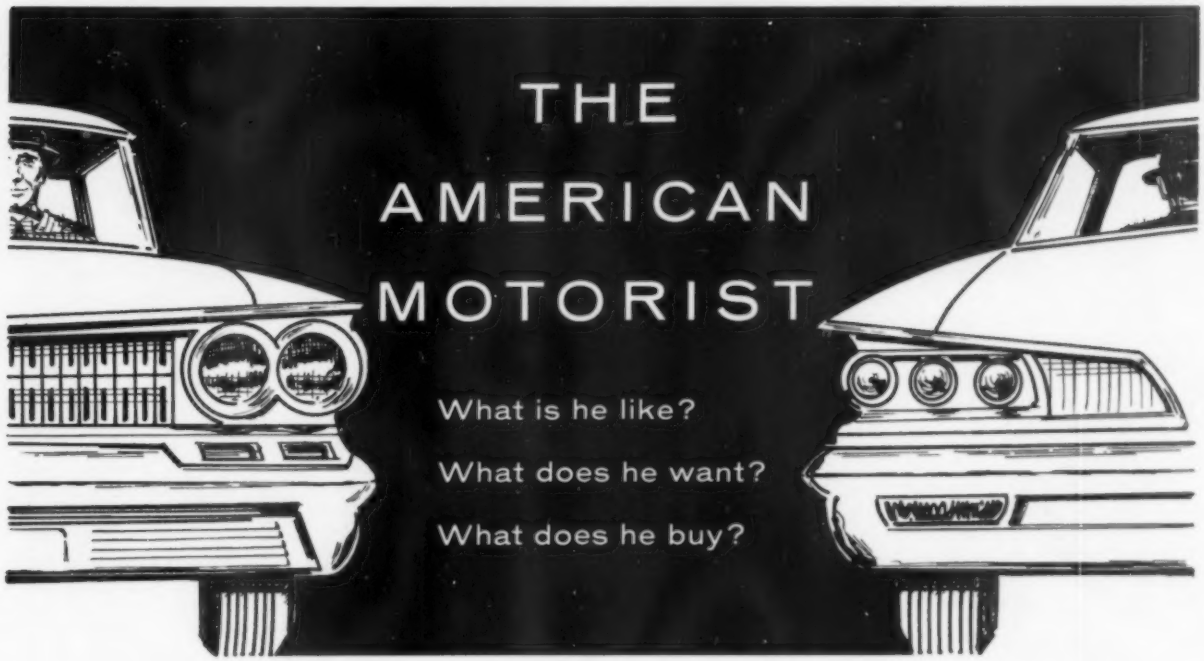

**MEET THE AUTHOR**

DWIGHT M. McMAKIN is manager of the engine and compressor products department, American Air Filter Company, Inc., Louisville, Kentucky, where his basic concern is application engineering. He has been with the company since receiving a BSEE degree from the University of Kentucky in 1938, except for three years during World War II when he served in the signal corps. McMakin is a registered professional engineer and member of the oil and gas power division of ASME.

DU PONT *Petroleum Chemicals* NEWS

Number 106 in a series of bulletins for the Petroleum Industry

JANUARY • FEBRUARY 1961




# New DuPont study of 4,507 motorists reveals latest trends in buying habits

*Are motorists becoming more loyal to their local service stations . . . or less?*

*How much influence do give-aways have in the motorist's choice of gasolines?*

*What percentage of people use their cars on vacations? How popular are credit cards? How do they influence buying habits?*

These are just a handful of the questions answered by DuPont's newest survey, "Profile of the Motorist"– the fourth in a series that constitutes the most complete study ever made of the American motoring public.

From coast to coast, 4,507 motorists were interviewed in this survey. Each interview was a penetrating study of the person's likes and dislikes, and his or her buying habits. Some 61 questions were asked, ranging from "Did you buy at a station with lower prices during a price war?" and "Do you still usually buy your gasoline at this station?" to "Do you have access to a private swimming pool?" and "Where did you spend your last vacation?"

The result of this interviewing is a vast array of data which has been fed into a processing system from which various combinations of facts can be extracted to answer specific questions for oil marketers.

### Your questions answered

The "Profile of the Motorist" survey is part four of DuPont's continuing investigations (begun in 1952) into the patterns of motorists' buying habits. These studies are offered to the industry as a service from DuPont.

For further information, contact your DuPont Petroleum Chemicals representative.

### Man with the facts

at DuPont is Roberts W. Brokaw, survey analyst in the Special Services Section, who is in charge of assembling data from the "Profile of the Motorist" study to answer specific questions for DuPont customers. Mr. Brokaw has been with the Petroleum Chemicals Division since its formation in 1947 and has supervised all previous motorist studies.

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

OVER

# DUPONT *Petroleum Chemicals* NEWS

## The show about the road is now on the road

Every road in America leads to adventure.

This, in seven words, is the theme behind one of the oil industry's newest travel development tools – DuPont's new half-hour color movie, "Highway Holiday."

"Highway Holiday" is a 16mm version of the CinemaScope feature "Down the Road," which is now being distributed to theaters across the nation by 20th Century-Fox. "Holiday" is designed for non-paying showings to any interested group. Both films are part of DuPont's marketing services to the oil industry.

"Highway Holiday" takes the audience to all corners of the American continent – from the sweeping highway across the Painted Desert to a historic old village in New England, from the gleaming sands of Daytona to the majestic mountains of Canada, from Quebec to Mexico.

All this travel has a meaning. "Highway Holiday" will encourage a greater appreciation of the heritage and beauties of America, and stimulate motorists' interest in seeing them firsthand

through the convenience and comfort of the family car.

**Prints available**

You can obtain prints of "Highway Holiday" for showing to clubs and other groups, or for local television use. The film is intended to provide you, as a marketer of gasoline and other oil products, with a *broad* "expand-the-demand" promotion, as a backdrop for your own travel development activities.

For further information, contact your DuPont Petroleum Chemicals representative.

## Low-cost way to break foam in gas scrubbing

Here is a new wrinkle that is already helping several companies to cut the cost of foam breaking in atmospheric and vacuum distillation processes.

The foam-killer that makes this possible is DuPont's OCENOL,® which is already well known for its anti-foam advantages in amine processes for removing $H_2S$ and $CO_2$ from liquid hydrocarbons, natural and refinery gases.

OCENOL carries a low price tag, and works effectively in small concentrations of only 0.1 to 0.3 lb. per 1,000 barrels. The result is that you pay a very low price to break foam with OCENOL.

**Facts in data sheet**

OCENOL is a technical grade of oleyl alcohol, rich in cetyl and unsaturated $C_{16}$ alcohols. It is available in two forms: OCENOL and OCENOL P. OCENOL P contains a lower proportion of unsaturates than OCENOL. In some applications, the products can be used interchangeably.

For information, contact your DuPont Petroleum Chemicals representative.

## ASSISTANT GENERAL MANAGER

**CARL S. OLDACH** is Assistant General Manager of DuPont's Organic Chemicals Department, one of the divisions of which is Petroleum Chemicals.

Mr. Oldach joined the company in 1940, as a senior chemical engineer in the Ammonia Department (now the Polychemicals Department) laboratories at the Experimental Station in Wilmington. In succeeding years he held several technical management positions in the department, and in 1955 he became Assistant Director of the Development Department. In 1958 he was transferred to the Organic Chemicals Department as Director of Sales of the Freon® Products Division. In May 1960, he was appointed to his present post as Assistant General Manager of the department.

Mr. Oldach has a Doctor of Science degree in chemical engineering from the Massachusetts Institute of Technology, in addition to his Bachelor of Science degree from Yale University.

He has published a number of scientific articles relating to analysis of sulfur compounds in gases. He is a member of the General Committee of the Refining Division of the API, and also holds memberships in the American Institute of Chemical Engineers and the American Chemical Society.

Born November 28, 1914 in San Diego, Calif., Mr. Oldach now lives in Wilmington, Del. with his wife, two daughters and son.

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## DuPont Lead Antiknock Compounds and other Petroleum Additives

OVER

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# mathematics workshop

DR. J. M. MARCHELLO, *Oklahoma State University*

## GEOMETRY | *part 2*

D. **Equations of Curves**

Plotting the graph of an equation point-by-point is often laborious and may give inadequate information about the form of the curve. In many cases an examination of the equation of the locus will indicate properties of the curve which make it possible to draw the curve from only a few well chosen points by making use of these properties of the graph. Some of the more important properties of a locus that can be determined from its equation are the intercepts, symmetry, and asymptotes.

**Intercepts:** The points of a locus that can be most easily located on the graph of an equation are the places where the curve intersects the coordinate axes.

**Symmetry:** Two points are symmetric with respect to a given point if the point lies on the mid-point of a line segment joining the two points. Similarly, two points are symmetric with respect to a given line if the line is the perpendicular bisector of a line segment joining the two points.

**Asymptotes:** When the graph of an equation has one or more straight lines related to it in such a manner that the curve approaches the line or lines as a limit, the line or lines are said to be an asymptote of the curve.

An equation which is used extensively in engineering work is

$$y = ax^b \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Classic examples of the application of this equation occur in dimensional analysis for the correlation of such important qualities as fluid friction factor and heat transfer coefficients.

A linear form of Equation 1 is obtained by taking the logarithm

$$\ln y = \ln a + b \ln x \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

On log-log paper this expression represents a straight line with intercepts ln a and slope b. The general behavior of this equation is shown in Fig. 1 and 2.

Some of the important properties of Equation 1 are.

$$x = 0, \text{ for } \begin{cases} b > 0, y = 0 \\ b < 0, y = \infty \end{cases}$$

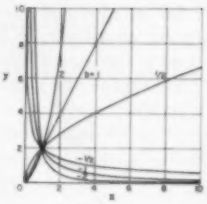


FIG. 1.

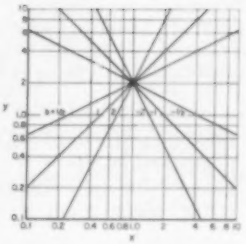


FIG. 2.

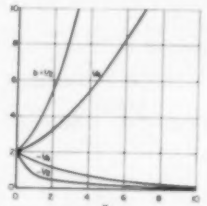


FIG. 3.

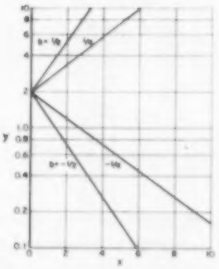


FIG. 4.

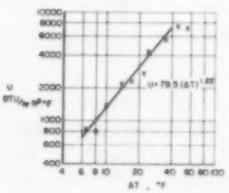


FIG. 5.

$$x = 1, \text{ for all values of b, } y = a$$

$$x = \infty, \text{ for } \begin{cases} b > 0, y = \infty \\ b < 0, y = 0 \end{cases}$$

For the trivial case of $b = 0$, y is equal to the constant a.

Another general equation of great utility in scientific and engineering analysis is:

$$y = ae^{bx} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

taking the natural logarithm

$$\ln y = \ln a + bx$$

On semi-log paper this expression represents a straight line with intercept ln a and slope b. The general behavior of Equation 3 is shown in Fig. 3 and 4.

Some of the characteristics of Equation 3 are:

when:

$x = 0$, for all values of b, $y = a$

$x = \infty$, for $\begin{cases} b > 0, y = \infty \\ b < 0, y = 0 \end{cases}$

Again for the trivial case of $b = 0$, y is equal to a.

Consideration of Fig. 1 through 4 indicates that when log-log and semi-log paper are used to represent the locus of Equations 1 and 3 it is not possible to obtain values of the constant a directly from the graphs and instead analytical methods must be used. Also the slope must be obtained by measurement of the distances directly rather than by use of the values of the coordinates. Another important characteristic of the log-log and semi-log plots are the added emphasis which they place on small values of the variables on the logarithmic coordinates.

A number of other types of graph paper are commercially available for plotting specific families of equations. For example, there are several types of probability paper available which enable one to plot error and distribution functions.

## PROBLEM 9

### Boiling Heat Transfer Correlation

In experiments with a new type of heat exchanger the following data were obtained for water boiling at one atmosphere:

| Overall Heat Transfer Coefficient U, Btu/hr ft² F | Overall Temperature Difference, ΔT, F |
|---|---|
| 840 | 6.5 |
| 800 | 8.0 |
| 1370 | 10.0 |
| 2150 | 14.0 |
| 2300 | 17.0 |
| 2750 | 22.0 |
| 4300 | 24.0 |
| 5800 | 35.0 |
| 7300 | 45.0 |
| 7100 | 55.0 |

Further development and design of this new exchanger requires that a correlation be obtained for these data. Suggest an empirical equation and discuss its limitations.

**Solution**

A log-log plot of the data indicates that the data may be represented by an equation of the form

$$U = A\,(\Delta T)^B \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9\text{-}1)$$

Fig. 5 also indicates that an equation of this type will only apply up to a ΔT of about 40 F. The reason for this is that the boiling mechanism changes from nucleate to film boiling in the region between a ΔT of 40 F and one of 70 F after which the coefficient begins to decrease.

A best line can be obtained by the least squares method discussed in problem 8 if $y = \ln U$ and $x = \ln(\Delta T)$. A fair correlation can be obtained by drawing a best line by eye on the plot and using it to determine the constants in Equation 9-1.

Two points on a line drawn in this manner are ($\Delta T = 8$, $U = 1000$) and ($\Delta T = 5000$). Taking the natural logarithm of Equation 9-1

$$\ln U = \ln A + B \ln(\Delta T) \quad . \quad . \quad . \quad (9\text{-}2)$$

Substituting these two points into Equation 9-2 yields two equations in two unknowns which can be solved for the empirical constants.

$$\ln (1000) = \ln A + B \ln(8) \quad . \quad . \quad (9\text{-}3)$$

$$\ln (5000) = \ln A + B \ln(30) \quad . \quad . \quad (9\text{-}4)$$

Subtracting and regrouping these equations

$$\ln \left(\frac{1000}{5000}\right) = B \ln \left(\frac{8}{30}\right). \quad . \quad . \quad (9\text{-}5)$$

From which

$B = 1.22$

Resubstituting into Equation 9-3 gives

$$\ln A = \ln(1000) - 1.22 \ln(8) \quad . \quad . \quad (9\text{-}6)$$

From which

$A = 79.5$

Then the equation representing the best line drawn by eye is

$$U = 79.5\ (\Delta T)^{1.22} \quad . \quad . \quad . \quad . \quad . \quad . \quad (9\text{-}7)$$

Equation 9-7 is an empirical representation of the variation of the boiling heat transfer coefficient with temperature difference for the range $6.5 < \Delta T < 40$ F.

## PROBLEM 10

### Production Change-Over for An Alkylation Plant

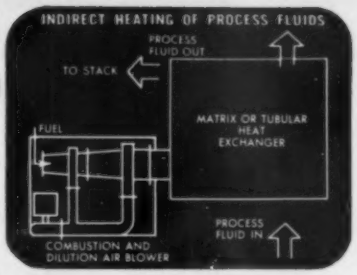
Changes in gasoline blending requirements indicate that the alkylation plant described in Problem 1 (June '60) must have its production rate changed to produce 100,000 bbl of light alkylate and 50,000 bbl of medium alkylate per month. When the plant was started up it was placed on stream at a 1.75 light to medium alkylate ratio. It has operated continuously at this product ratio except for one short period when there was special demand for medium alkylate.

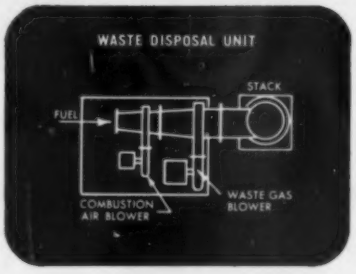
The start-up data varied considerably due to the usual problems and is not of much use in determining the time required for this new production change. Data taken during the change to medium alkylate production and back again to the 1.75 product ratio are as follows:

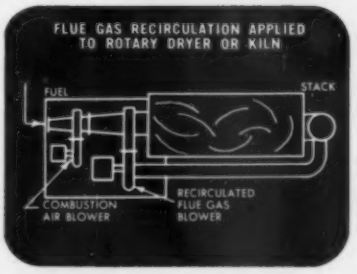
| Time (hour and day) | Product Ratio (bbl light/bbl medium) |
|---|---|
| 8 a.m., 6/12 | 1.75 |
| 8 p.m., 6/12 | 1.23 |
| 8 a.m., 6/13 | 0.89 |
| 8 a.m., 6/14 | 0.53 |
| 8 a.m., 6/15 | 0.20 |
| 8 a.m., 8/3 | 0.00 |
| 8 p.m., 8/3 | 0.52 |
| 8 a.m., 8/4 | 0.84 |
| 8 a.m., 8/5 | 1.37 |

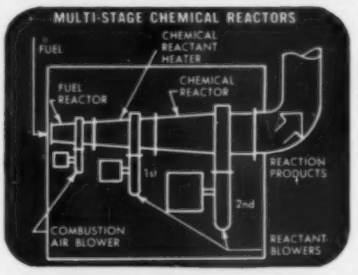
Suggest a procedure for making the change to the new production schedule as rapidly as possible and develop a relationship for predicting the product distribution during this change over.

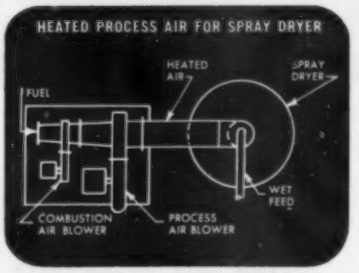
PETRO/CHEM CLIP/FILE

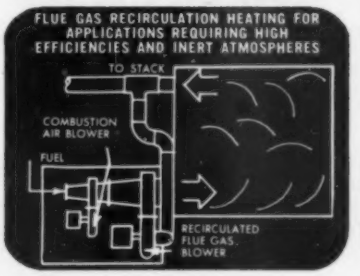
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TO STACK
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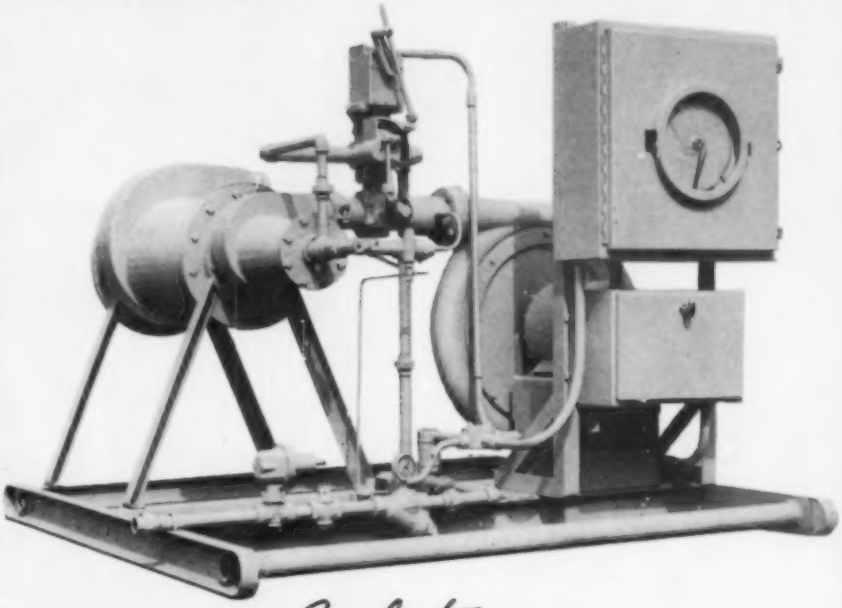
FUEL
RECIRCULATED FLUE GAS BLOWER

# BS&B "Q"-PAK

## PACKAGED DIRECT-FIRED HEATERS



## The ~~Hottest~~ *Coolest* Thing in Heaters

### *HERE'S WHY:*

- High heat release, rates up to 10,000,000 BTU/Hr. per cubic foot of combustion volume.
- "Q"-PAK needs no refractory lining even at temperatures of 3000° F. outlet, because outer surfaces are air cooled.
- This completely sealed unit is safe for use in fire hazardous areas.
- Flame stability over a wide range of air to fuel ratios . . . No flame flashback . . . No flame extension . . . Designed to give maximum protection against loss of flame due to overfiring.
- High intensity mixing assures complete combustion: hence produces clean, hot air or gas . . . Provides inert gas generation if required.
- "Q"-PAK operates under vacuum, atmospheric or high pressure situations.
- Burns low pressure, very low BTU content fuels and heats to maximum in minutes (even seconds) from a cold start.
- Completely packaged unit—ready for immediate operation.

That's why we say it is the coolest development in heaters. Just a few of the hundreds of applications are shown here . . . why not find out where "Q"-PAK fits into your process and how it can work for you?

Write to Black, Sivalls & Bryson, Inc., Dept. 1-GX2 7500 East 12th St., Kansas City, Missouri.

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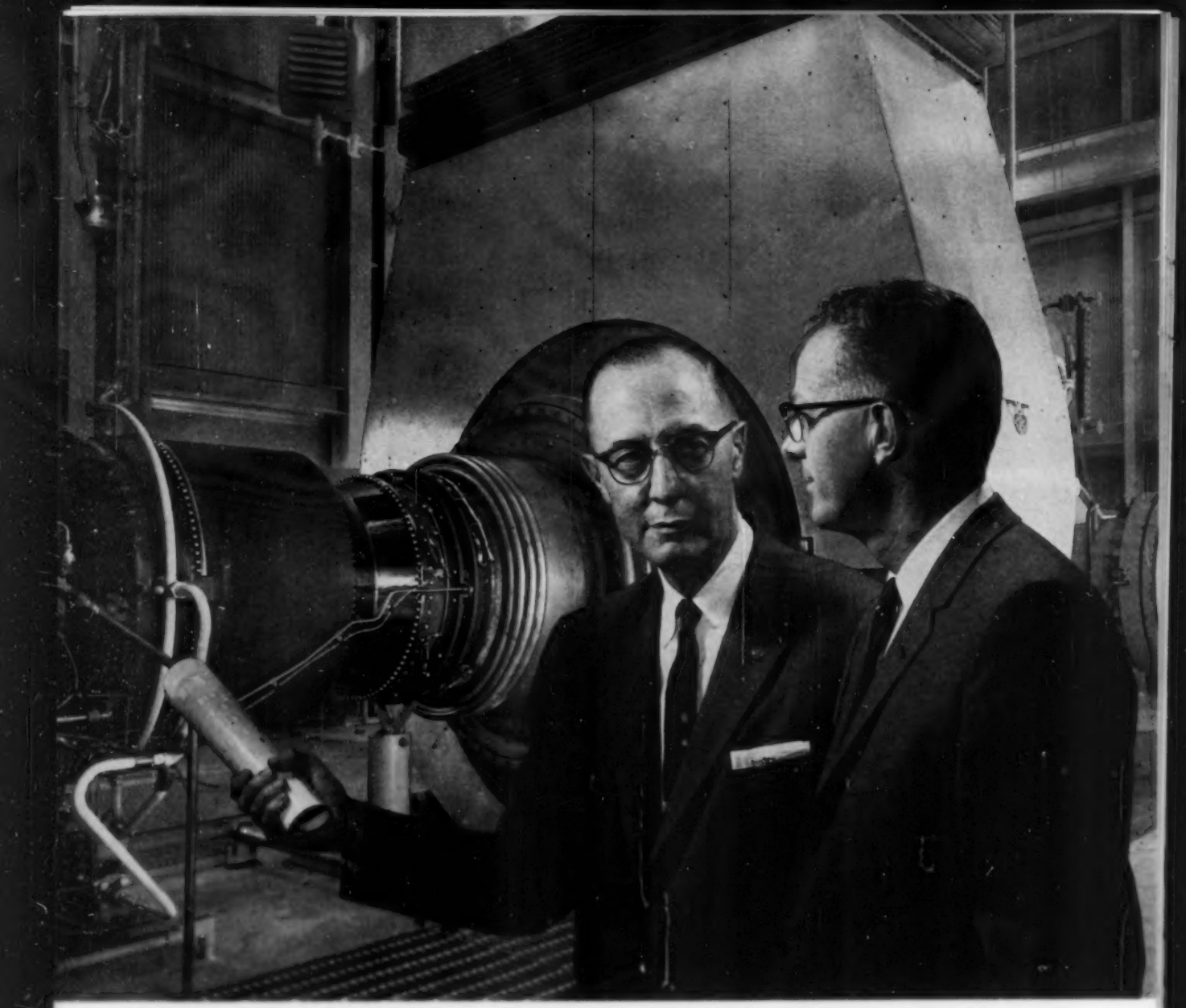

**R. L. Boyer,** ***Vice President and Director of Engineering, and*** **W. B. Boyum,**
***Manager of Gas Turbine Sales, The Cooper-Bessemer Corporation report...***

used in selecting the filter size should be adjusted for the difference in volume caused by the change in temperature across the cooler. It is possible to get

which not only will provide an adequate degree of dirt removal to prevent blade erosion, but will be compact in size, low in maintenance, acceptable in

years during World War II when he served in the signal corps. McMakin is a registered professional engineer and member of the oil and gas power division of ASME.

# PETRO/CHEM new equipment

### Unit provides programmed column operation for gas chromatographs

New Model 22 accessory unit provides programmed column operation from ambient to 500 C for existing gas chromatographic units which do not have column programming. Accessory is designed with a split flow system that uses both a reference column and a sample column. The sample column connects to the gas chromatograph sample detector cell and the reference column connects to the gas chromatograph reference detector cell. This balanced system compensates for the background vapor pressure of the column packing during programming. It is also possible to use either column as an analytical column with different packings for fixed temperature operation, or for programming over narrower temperature spans. *Loe Engineering Company.*

Circle number (41) on reply card.

### New mobile computer designed to monitor chemical processes

On-site data processing capabilities not preivously available in mobile equipment are provided in new system comprised of a PB 250 digital computer installed in a van. System is feasible because the PB 250 computer can be supplied with power from a battery for operation where no a-c power line is accessible. First unit of this type, being manufactured for Shell Chemical, will be used to monitor chemical process performance at various plant locations. *Packard Bell Computer Corporation.*

Circle number (42) on reply card.

### Temperature regulators for storage type heating and cooling services

Leslie-Eventemp temperature regulator line meets need for a regulator that will "full stroke" the valve with a smaller temperature change than for vapor pressure or gas filled type regulators used in storage type heating and cooling services. Available with cast iron or bronze bodies, with screwed or flanged ends in a range of sizes from ½ to 4 in. *Leslie Co.*

Circle number (43) on reply card.

### Calculating device is time saver for catalytic cracking operators

[illegible] Catalytic [illegible] which [illegible] and interested in this [illegible]

Suitable for use with liquid oxygen, gaseous oxygen and nitrogen, liquid nitrogen, hydrogen peroxide, inhibited red fuming nitric acid, hydrogen tetroxide, oil, steam, water and refrigerants. Standard models in ¼, ⅜, ½, ⅝, ¾, 1, and 1¼-in. sizes. No size limitation on special designs. Sizes ¼ through 1-in. proof rated at 4500 psi, burst at 7500 psi. Size 1¼-in. proof rated at 900 psi, burst at 1500 psi. *Jack & Heintz, Inc.*

Circle number (45) on reply card.

### "Q"-PAK direct fired air heater has high combustion efficiency

Extremely high combustion efficiency and absence of impurities are hailed as principal features of "Q"-PAK, a new direct fired air heater. Basic uses include heating of process air for fluidized bed dryers or spray dryers; direct heating of furnaces, ovens, dryers, or kilns; indirect heating of process fluids; multi-heater temperature zone control on continuous dryers or kilns; packaged waste disposal units; and packaged multi-stage chemical reactors. Where extremely high efficiencies and intert atmospheres are required, the "Q"-PAK may also be incorporated in flue gas recirculation heating systems. Available in sizes ranging from 100,000 to 10,000,000 Btu per hr heat release. *Black, Sivalls & Bryson, Inc.*

Circle number (46) on reply card.

### Depressuring safety valve meets API Tentative Standard RP-520

S & J Model 4280 depressuring safety valve is designed to meet requirements as set forth in API Tentative Standard RP-520. Valve is energized by pressure in the vessel being protected, product vapor pressure being applied to the upper portion of the disc through appropriate piping. *Shand and Jurs Company.*

Circle number (47) on reply card.

### Submersible a-c motors for close coupling to centrifugal pumps

New line of submersible, pressure-proof a-c motors is designed for close-coupling to centrifugal pumps operating in any depth of water, oil, or liquid chemicals. Available in [illegible] through 40 hp for operation from [illegible]


. . . one of a series presented by Western Supply Company, Tulsa, to improve the "I.Q."* of engineers . . . (*"Income Quotient")

## Personal, professional advancement demands thorough engineering knowledge, disciplined habits, creative thinking, constant application

"Intellectual let-down" — that tendency so common to many engineers to "stop learning" as soon as they acquire a sheepskin — will be completely out of style by 1999. Indeed, it is passe in today's accelerated engineering profession, because to stop learning is to stop growing: to stifle imagination, to throttle creativity, and ultimately to kill scientific progress.

The engineer who would keep pace with his own industry — especially the process industry — must determine to follow a prescribed, disciplined course of action, if he is to achieve the stature, prestige, responsibility and income to which he aspires. He must recognize that only as his engineering achievement advances will his personal well-being also increase.

There is no magic formula for the "successful engineer," but for what they are worth to your professional future, here are 14 "ground rules" for your consideration:

**Set objectives** for your professional and personal life, re-examine them periodically, but always work towards a goal in life.

**Develop sound work habits.** Earn a reputation for promptness, attention to detail, accuracy, diligence, reliability.

**Continue to study** your chosen field or specialty. Your learning process must never cease functioning.

**Seek additional training,** technically or in non-technical fields which can be of importance to future development.

**Think creatively** about your job, your company, technological advances and developments. Dare to think **beyond** your capacity.

**Expand your capacity** to discover new fields of endeavor, discriminatingly, however, so that they will have application to your objectives.

**Take a genuine interest in people,** their potentials, their problems. Understand, but don't condemn, their shortcomings.

**Broaden your base** of appreciation for other pursuits, such as sales, accounting, law, advertising. They, too, are important to your company.

**Study the fundamentals** of business. Learn the economics of your company, its basic philosophy, its obligations and responsibilities, its opportunities and [illegible]

Se[illegible] advice and counsel from others.

[illegible]


interview was a penetrating study of the person's likes and dislikes, and his or her buying habits. Some 61 questerns of motorists' buying habits. These studies are offered to the industry as a service from DuPont.

law has been with the Petroleum Chemicals Division since its formation in 1947 and has supervised all previous motorist studies.


ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

OVER

# DUPONT *Petroleum Chemicals* NEWS

## The show about the road is now on the road

Every road in America leads to adventure.

This, in seven words, is the theme behind one of the oil industry's newest travel development tools – DuPont's new half-hour color movie, "Highway Holiday."

"Highway Holiday" is a 16mm version of the CinemaScope feature "Down the Road," which is now being distributed to theaters across the nation by 20th Century-Fox. "Holiday" is designed for non-paying showings to any interested group. Both films are part of DuPont's marketing services to the oil industry.

"Highway Holiday" takes the audience to all corners of the American continent – from the sweeping highway across the Painted Desert to a historic old village in New England, from the gleaming sands of Daytona to the majestic mountains of Canada, from Quebec to Mexico.

All this travel has a meaning. "Highway Holiday" will encourage a greater appreciation of the heritage and beauties of America, and stimulate motorists' interest in seeing them firsthand

through the convenience and comfort of the family car.

**Prints available**

You can obtain prints of "Highway Holiday" for showing to clubs and other groups, or for local television use. The film is intended to provide you, as a marketer of gasoline and other oil products, with a *broad* "expand-the-demand" promotion, as a backdrop for your own travel development activities.

For further information, contact your DuPont Petroleum Chemicals representative.

## ASSISTANT GENERAL MANAGER

**CARL S. OLDACH** is Assistant General Manager of DuPont's Organic Chemicals Department, one of the divisions of which is Petroleum Chemicals.

Mr. Oldach joined the company in 1940, as a senior chemical engineer in the Ammonia Department (now the Polychemicals Department) laboratories at the Experimental Station in Wilmington. In succeeding years he held several technical management positions in the department, and in 1955 he became Assistant Director of the Development Department. In 1958 he was transferred to the Organic Chemicals Department as Director of Sales of the Freon® Products Division. In May 1960, he was appointed to his present post as Assistant General Manager of the department.

Mr. Oldach has a Doctor of Science degree in chemical engineering from the Massachusetts Institute of Technology, in addition to his Bachelor of Science degree from Yale University.

He has published a number of scientific articles relating to analysis of sulfur compounds in gases. He is a member of the General Committee of the Refining Division of the API, and also holds memberships in the American Institute of Chemical Engineers and the American Chemical Society.

Born November 28, 1914 in San Diego, Calif., Mr. Oldach now lives in Wilmington, Del. with his wife, two daughters and son.

## Low-cost way to break foam in gas scrubbing

Here is a new wrinkle that is already helping several companies to cut the cost of foam breaking in atmospheric and vacuum distillation processes.

The foam-killer that makes this possible is DuPont's OCENOL,® which is already well known for its anti-foam advantages in amine processes for removing $H_2S$ and $CO_2$ from liquid hydrocarbons, natural and refinery gases.

OCENOL carries a low price tag, and works effectively in small concentrations of only 0.1 to 0.3 lb. per 1,000 barrels. The result is that you pay a very low price to break foam with OCENOL.

**Facts in data sheet**

OCENOL is a technical grade of oleyl alcohol, rich in cetyl and unsaturated $C_{16}$ alcohols. It is available in two forms: OCENOL and OCENOL P. OCENOL P contains a lower proportion of unsaturates than OCENOL. In some applications, the products can be used interchangeably.

For information, contact your DuPont Petroleum Chemicals representative.

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**New York 20**–45 Rockefeller Plaza ..... COlumbus 5-2342
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**Pittsburgh 22**–1 Gateway Center ... ATlantic 1-2933
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## DuPont Lead Antiknock Compounds and other Petroleum Additives

OVER

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DR. J. M. MARCHELLO, Oklahoma State University

CLIP/FILE

PETRO/CHEM

# GEOMETRY | part 2

## D. Equations of Curves

Plotting the graph of an equation point-by-point is often laborious and may give inadequate information about the form of the curve. In many cases an examination of the equation of the locus will indicate properties of the curve which make it possible to draw the curve from only a few well chosen points by making use of these properties of the graph. Some of the more important properties of a locus that can be determined from its equation are the intercepts, symmetry, and asymptotes.

**Intercepts:** The points of a locus that can be most easily located on the graph of an equation are the places where the curve intersects the coordinate axes.

**Symmetry:** Two points are symmetric with respect to a given point if the point lies on the mid-point of a line segment joining the two points. Similarly, two points are symmetric with respect to a given line if the line is the perpendicular bisector of a line segment joining the two points.

**Asymptotes:** When the graph of an equation has one or more straight lines related to it in such a manner that the curve approaches the line or lines as a limit, the line or lines are said to be an asymptote of the curve.

An equation which is used extensively in engineering work is

$$y = ax^b \quad \ldots\ldots\ldots\ldots \quad (1)$$

Classic examples of the application of this equation occur in dimensional analysis for the correlation of such important qualities as fluid friction factor and heat transfer coefficients.

A linear form of Equation 1 is obtained by taking the logarithm

$$\ln y = \ln a + b \ln x \quad \ldots\ldots\ldots \quad (2)$$

On log-log paper this expression represents a straight line with intercepts ln a and slope b. The general behavior of this equation is shown in Fig. 1 and 2.

Some of the important properties of Equation 1 are.

$$x = 0, \text{ for } \begin{cases} b > 0, y = 0 \\ b < 0, y = \infty \end{cases}$$

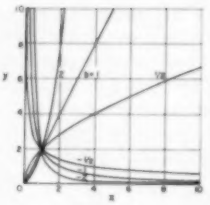


FIG. 1.

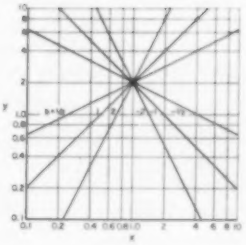


FIG. 2.

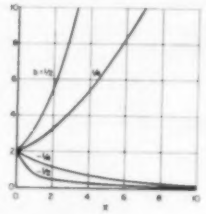


FIG. 3.

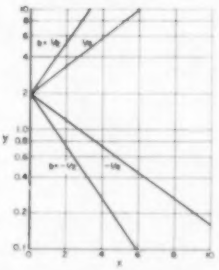


FIG. 4.

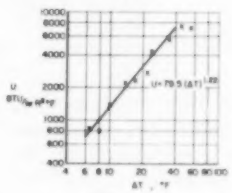


FIG. 5.

$$x = 1, \text{ for all values of b, } y = a$$

$$x = \infty, \text{ for } \begin{cases} b > 0, y = \infty \\ b < 0, y = 0 \end{cases}$$

For the trivial case of $b = 0$, y is equal to the constant a.

Another general equation of great utility in scientific and engineering analysis is:

$$y = ae^{bx} \quad \ldots\ldots\ldots\ldots \quad (3)$$

taking the natural logarithm

$$\ln y = \ln a + bx$$

On semi-log paper this expression represents a straight line with intercept ln a and slope b. The general behavior of Equation 3 is shown in Fig. 3 and 4.

Some of the characteristics of Equation 3 are:

when:

$x = 0$, for all values of b, $y = a$

$x = \infty$, for $\begin{cases} b > 0, y = \infty \\ b < 0, y = 0 \end{cases}$

Again for the trivial case of $b = 0$, y is equal to a.

Consideration of Fig. 1 through 4 indicates that when log-log and semi-log paper are used to represent the locus of Equations 1 and 3 it is not possible to obtain values of the constant a directly from the graphs and instead analytical methods must be used. Also the slope must be obtained by measurement of the distances directly rather than by use of the values of the coordinates. Another important characteristic of the log-log and semi-log plots are the added emphasis which they place on small values of the variables on the logarithmic coordinates.

A number of other types of graph paper are commercially available for plotting specific families of equations. For example, there are several types of probability paper available which enable one to plot error and distribution functions.

## PROBLEM 9

### Boiling Heat Transfer Correlation

In experiments with a new type of heat exchanger the following data were obtained for water boiling at one atmosphere:

| Overall Heat Transfer Coefficient U, Btu/hr ft² F | Overall Temperature Difference, ΔT, F |
|---|---|
| 840 | 6.5 |
| 800 | 8.0 |
| 1370 | 10.0 |
| 2150 | 14.0 |
| 2300 | 17.0 |
| 2750 | 22.0 |
| 4300 | 24.0 |
| 5800 | 35.0 |
| 7300 | 45.0 |
| 7100 | 55.0 |

Further development and design of this new exchanger requires that a correlation be obtained for these data. Suggest an empirical equation and discuss its limitations.

**Solution**

A log-log plot of the data indicates that the data may be represented by an equation of the form

$$U = A\,(\Delta T)^B \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9\text{-}1)$$

Fig. 5 also indicates that an equation of this type will only apply up to a ΔT of about 40 F. The reason for this is that the boiling mechanism changes from nucleate to film boiling in the region between a ΔT of 40 F and one of 70 F after which the coefficient begins to decrease.

A best line can be obtained by the least squares method discussed in problem 8 if $y = \ln U$ and $x = \ln(\Delta T)$. A fair correlation can be obtained by drawing a best line by eye on the plot and using it to determine the constants in Equation 9-1.

Two points on a line drawn in this manner are ($\Delta T = 8$, $U = 1000$) and ($\Delta T = 5000$). Taking the natural logarithm of Equation 9-1

$$\ln U = \ln A + B \ln(\Delta T) \quad . \quad . \quad . \quad (9\text{-}2)$$

Substituting these two points into Equation 9-2 yields two equations in two unknowns which can be solved for the empirical constants.

$$\ln (1000) = \ln A + B \ln(8) \quad . \quad . \quad (9\text{-}3)$$

$$\ln (5000) = \ln A + B \ln(30) \quad . \quad . \quad (9\text{-}4)$$

Subtracting and regrouping these equations

$$\ln \left(\frac{1000}{5000}\right) = B \ln \left(\frac{8}{30}\right) . \quad . \quad . \quad (9\text{-}5)$$

From which

$B = 1.22$

Resubstituting into Equation 9-3 gives

$$\ln A = \ln(1000) - 1.22 \ln(8) \quad . \quad . \quad (9\text{-}6)$$

From which

$A = 79.5$

Then the equation representing the best line drawn by eye is

$$U = 79.5\ (\Delta T)^{1.22} \quad . \quad . \quad . \quad . \quad . \quad . \quad (9\text{-}7)$$

Equation 9-7 is an empirical representation of the variation of the boiling heat transfer coefficient with temperature difference for the range $6.5 < \Delta T < 40$ F.

## PROBLEM 10

### Production Change-Over for An Alkylation Plant

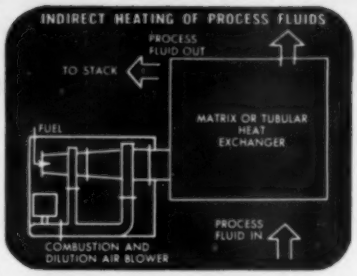
Changes in gasoline blending requirements indicate that the alkylation plant described in Problem 1 (June '60) must have its production rate changed to produce 100,000 bbl of light alkylate and 50,000 bbl of medium alkylate per month. When the plant was started up it was placed on stream at a 1.75 light to medium alkylate ratio. It has operated continuously at this product ratio except for one short period when there was special demand for medium alkylate.

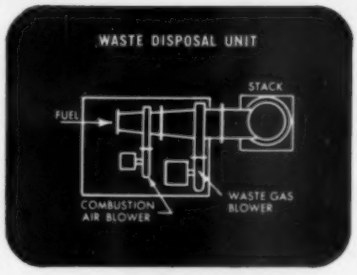
The start-up data varied considerably due to the usual problems and is not of much use in determining the time required for this new production change. Data taken during the change to medium alkylate production and back again to the 1.75 product ratio are as follows:

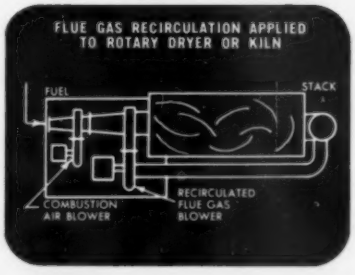
| Time (hour and day) | Product Ratio (bbl light/bbl medium) |
|---|---|
| 8 a.m., 6/12 | 1.75 |
| 8 p.m., 6/12 | 1.23 |
| 8 a.m., 6/13 | 0.89 |
| 8 a.m., 6/14 | 0.53 |
| 8 a.m., 6/15 | 0.20 |
| 8 a.m., 8/3 | 0.00 |
| 8 p.m., 8/3 | 0.52 |
| 8 a.m., 8/4 | 0.84 |
| 8 a.m., 8/5 | 1.37 |

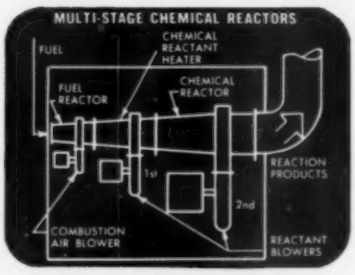
Suggest a procedure for making the change to the new production schedule as rapidly as possible and develop a relationship for predicting the product distribution during this change over.

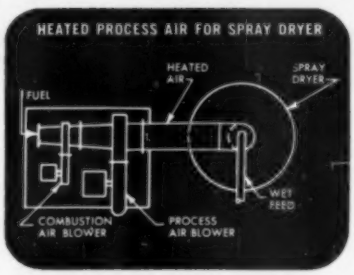
PETRO/CHEM CLIP/FILE

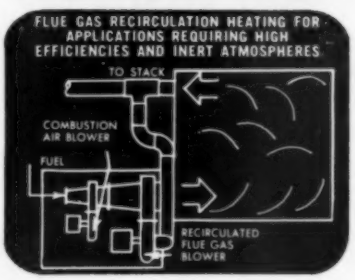
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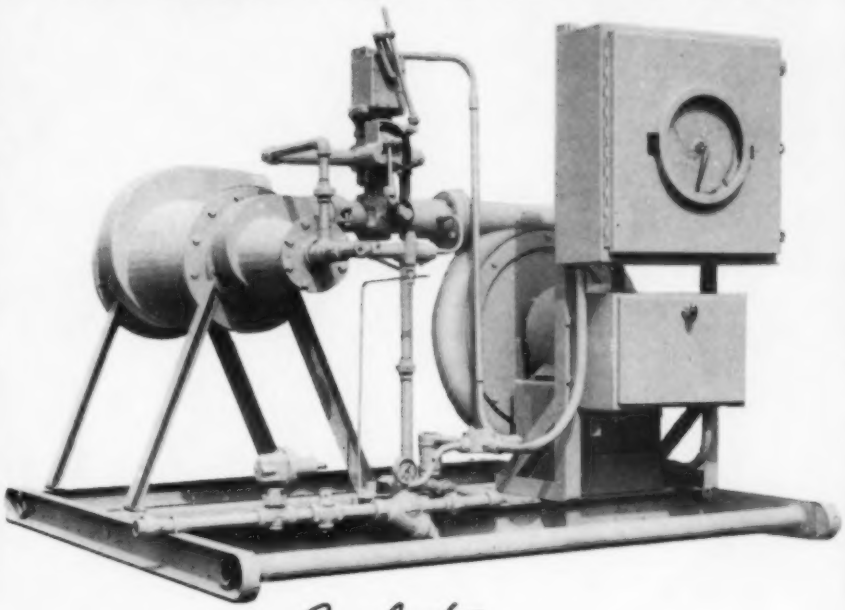

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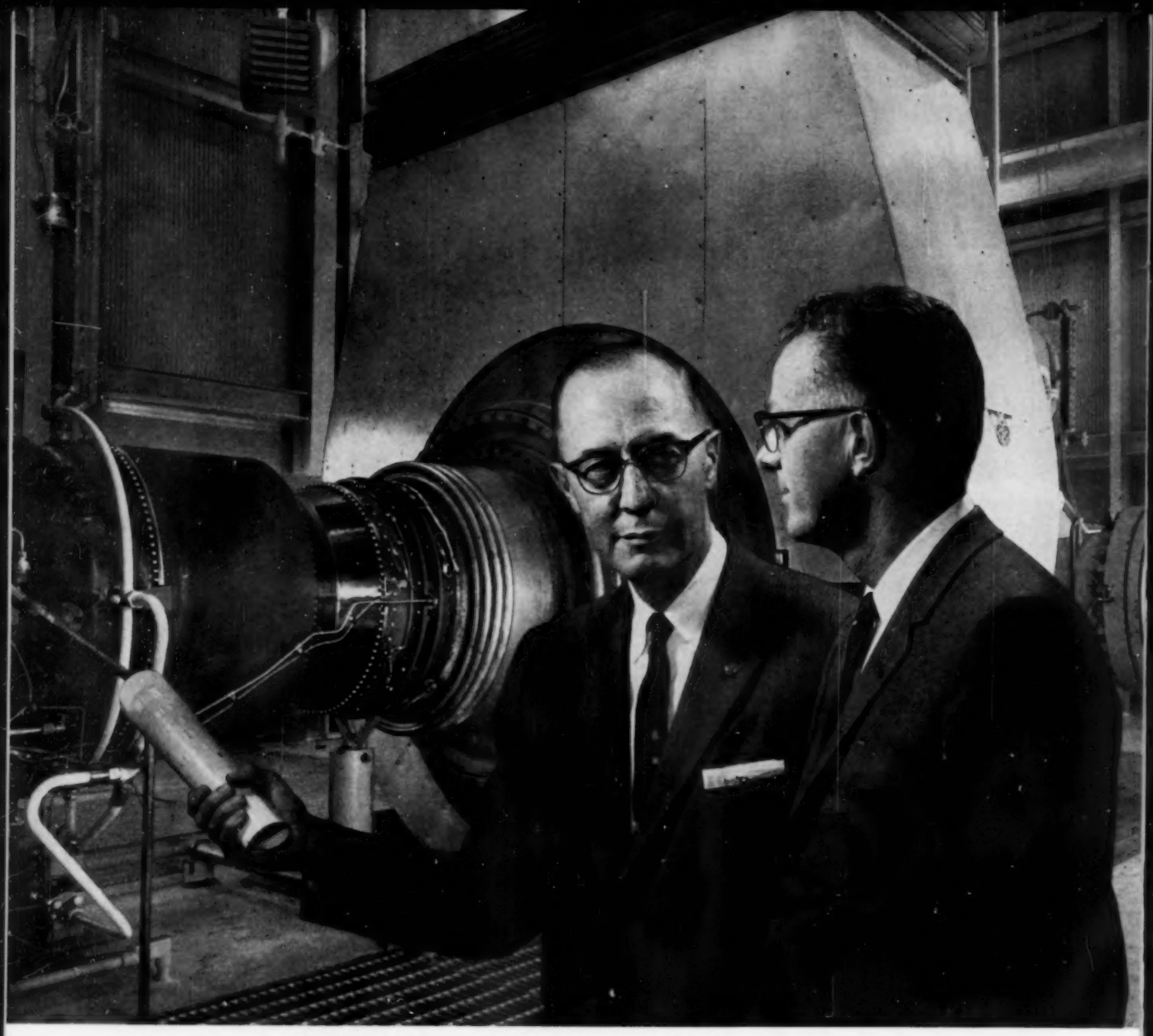

R. L. Boyer, *Vice President and Director of Engineering, and* W. B. Boyum, *Manager of Gas Turbine Sales, The Cooper-Bessemer Corporation report...*

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# PETRO/CHEM new equipment

### Unit provides programmed column operation for gas chromatographs

New Model 22 accessory unit provides programmed column operation from ambient to 500 C for existing gas chromatographic units which do not have column programming. Accessory is designed with a split flow system that uses both a reference column and a sample column. The sample column connects to the gas chromatograph sample detector cell and the reference column connects to the gas chromatograph reference detector cell. This balanced system compensates for the background vapor pressure of the column packing during programming. It is also possible to use either column as an analytical column with different packings for fixed temperature operation, or for programming over narrower temperature spans. *Loe Engineering Company.*

Circle number (41) on reply card.

### New mobile computer designed to monitor chemical processes

On-site data processing capabilities not preivously available in mobile equipment are provided in new system comprised of a PB 250 digital computer installed in a van. System is feasible because the PB 250 computer can be supplied with power from a battery for operation where no a-c power line is accessible. First unit of this type, being manufactured for Shell Chemical, will be used to monitor chemical process performance at various plant locations. *Packard Bell Computer Corporation.*

Circle number (42) on reply card.

### Temperature regulators for storage type heating and cooling services

Leslie-Eventemp temperature regulator line meets need for a regulator that will "full stroke" the valve with a smaller temperature change than for vapor pressure or gas filled type regulators used in storage type heating and cooling services. Available with cast iron or bronze bodies, with screwed or flanged ends in a range of sizes from ½ to 4 in. *Leslie Co.*

Circle number (43) on reply card.

### Calculating device is time saver for catalytic cracking operators

Davison Catulator, a unique plastic coated slide chart, 6½ by 12 in., provides refiners with a fast, easy means for calculating carbon burning rate, hydrogen on coke, catalyst inventories, and catalyst bed densities in fluid cracking units. Offers a rapid check on pencil calculations or can replace pencil calculations entirely where scale length is sufficient for required accuracy. Product service bulletin describes uses in detail. *Davison Chemical Division, W. R. Grace & Co.*

Circle number (44) on reply card.

### Minimum leakage on disconnect with new trigger lock coupling

Trigger Lock Series 17 no-air inclusion quick-connect coupling is designed for applications calling for minimum leakage on disconnect and minimum entrapment of air or other foreign matter on connect. Suitable for use with liquid oxygen, gaseous oxygen and nitrogen, liquid nitrogen, hydrogen peroxide, inhibited red fuming nitric acid, hydrogen tetroxide, oil, steam, water and refrigerants. Standard models in ¼, ⅜, ½, ⅝, ¾, 1, and 1¼-in. sizes. No size limitation on special designs. Sizes ¼ through 1-in. proof rated at 4500 psi, burst at 7500 psi. Size 1¼-in. proof rated at 900 psi, burst at 1500 psi. *Jack & Heintz, Inc.*

Circle number (45) on reply card.

### "Q"-PAK direct fired air heater has high combustion efficiency

Extremely high combustion efficiency and absence of impurities are hailed as principal features of "Q"-PAK, a new direct fired air heater. Basic uses include heating of process air for fluidized bed dryers or spray dryers; direct heating of furnaces, ovens, dryers, or kilns; indirect heating of process fluids; multi-heater temperature zone control on continuous dryers or kilns; packaged waste disposal units; and packaged multi-stage chemical reactors. Where extremely high efficiencies and intert atmospheres are required, the "Q"-PAK may also be incorporated in flue gas recirculation heating systems. Available in sizes ranging from 100,000 to 10,000,000 Btu per hr heat release. *Black, Sivalls & Bryson, Inc.*

Circle number (46) on reply card.

### Depressuring safety valve meets API Tentative Standard RP-520

S & J Model 4280 depressuring safety valve is designed to meet requirements as set forth in API Tentative Standard RP-520. Valve is energized by pressure in the vessel being protected, product vapor pressure being applied to the upper portion of the disc through appropriate piping. *Shand and Jurs Company.*

Circle number (47) on reply card.

### Submersible a-c motors for close coupling to centrifugal pumps

New line of submersible, pressure-proof a-c motors is designed for close-coupling to centrifugal pumps operating in any depth of water, oil, or liquid chemicals. Available in sizes from ½ through 40 hp for operation from polyphase power sources, and from ¾ through 5 hp for single-phase connection. Motors are rated at 55 C temperature rise for 30-min duty in 40 C air, and for continuous duty in 40 C liquids. *Reliance Electric and Engineering Company.*

Circle number (48) on reply card.

### New high pressure regulator has delivery up to 2500 psi

No. XX-87 high pressure regulator was developed for use in refineries, research laboratories, and general industry for such purposes as hydrogenation, catalytic reduction, calerimetry, accelerated age-testing, and pressure testing. Has a delivery of up to 2500 psi and is provided with 4000/4000-lb gages. *Harris Calorific Company.*

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## Personal, professional advancement demands thorough engineering knowledge, disciplined habits, creative thinking, constant application

"Intellectual let-down" — that tendency so common to many engineers to "stop learning" as soon as they acquire a sheepskin — will be completely out of style by 1999. Indeed, it is passe in today's accelerated engineering profession, because to stop learning is to stop growing: to stifle imagination, to throttle creativity, and ultimately to kill scientific progress.

The engineer who would keep pace with his own industry — especially the process industry — must determine to follow a prescribed, disciplined course of action, if he is to achieve the stature, prestige, responsibility and income to which he aspires. He must recognize that only as his engineering achievement advances will his personal well-being also increase.

There is no magic formula for the "successful engineer," but for what they are worth to your professional future, here are 14 "ground rules" for your consideration:

**Set objectives** for your professional and personal life, re-examine them periodically, but always work towards a goal in life.

**Develop sound work habits.** Earn a reputation for promptness, attention to detail, accuracy, diligence, reliability.

**Continue to study** your chosen field or specialty. Your learning process must never cease functioning.

**Seek additional training,** technically or in non-technical fields which can be of importance to future development.

**Think creatively** about your job, your company, technological advances and developments. Dare to think **beyond** your capacity.

**Expand your capacity** to discover new fields of endeavor, discriminatingly, however, so that they will have application to your objectives.

**Take a genuine interest in people,** their potentials, their problems. Understand, but don't condemn, their shortcomings.

**Broaden your base** of appreciation for other pursuits, such as sales, accounting, law, advertising. They, too, are important to your company.

**Study the fundamentals** of business. Learn the economics of your company, its basic philosophy, its obligations and responsibilities, its opportunities and limitations.

**Seek advice and counsel** from others; don't rely entirely on your own resources . . . Ask questions.

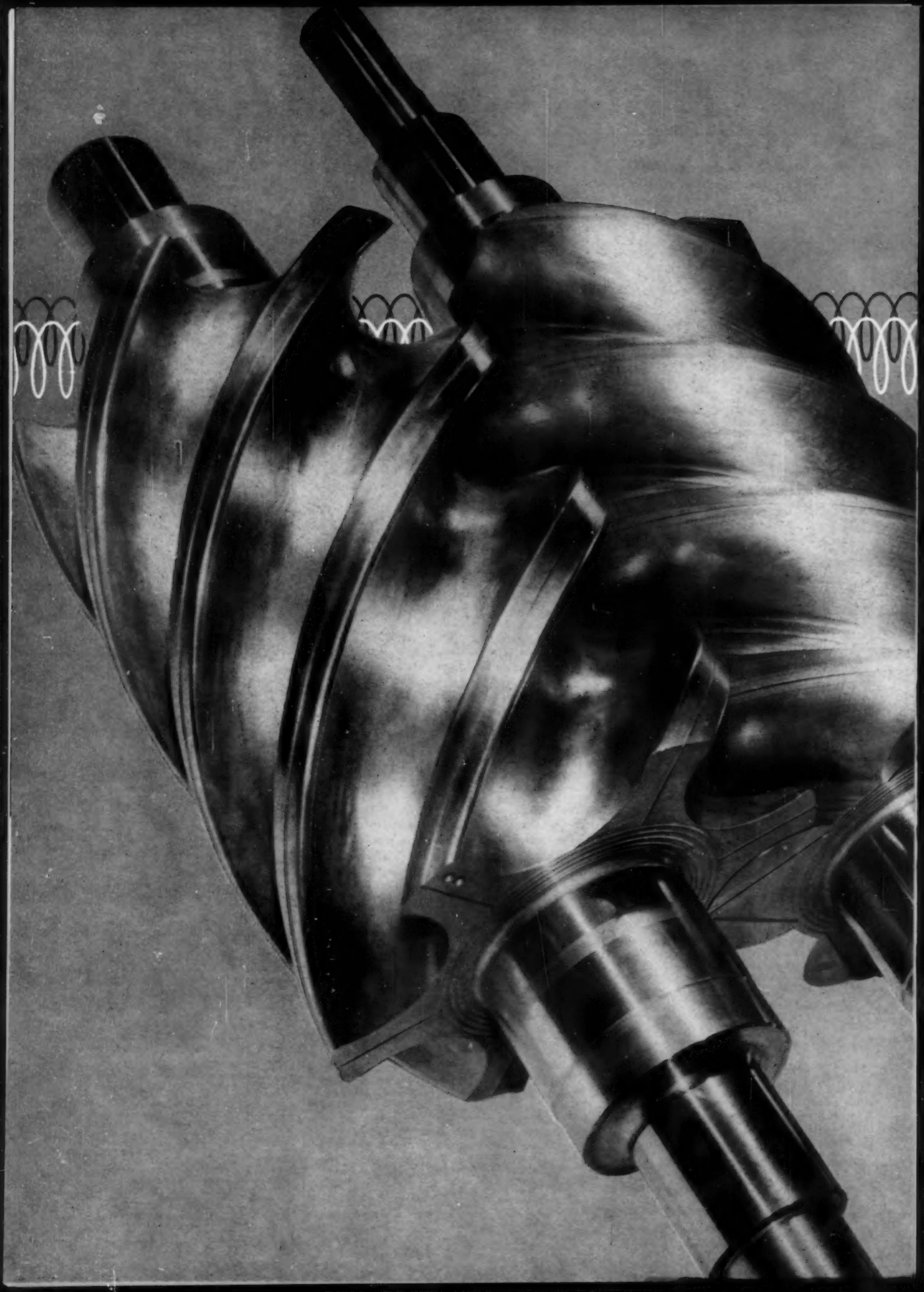
**Participate actively** in technical societies; keep alert to professional trends, changing concepts, new developments.

**Use common sense** and sound, practical judgment in evaluating everything from people to processes.

**Aggressively pursue** your professional and personal ambitions, but with patience and intelligence.

**Learn to communicate** your ideas and opinions pleasantly, clearly, concisely, aggressively to your superiors, associates, subordinates.

The development of a successful career in engineering requires **constant, consistent dedication** to professional and personal principles. These few paragraphs may serve as a guide for your own advancement and future, but for a more detailed discussion on this topic, write for your free copy of Booklet E-2, "Personal, Professional Advancement," to WESTERN SUPPLY COMPANY, HEAT EXCHANGER DIVISION, P. O. BOX 1888, TULSA, OKLA. — and if there's a heat exchanger in your company's future, we'd like to demonstrate how these same "ground rules" affect our heat exchangers.



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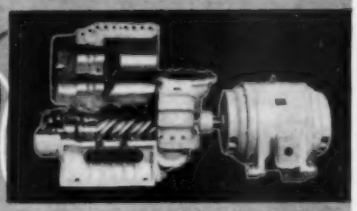

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Circle number (137) on reply card.

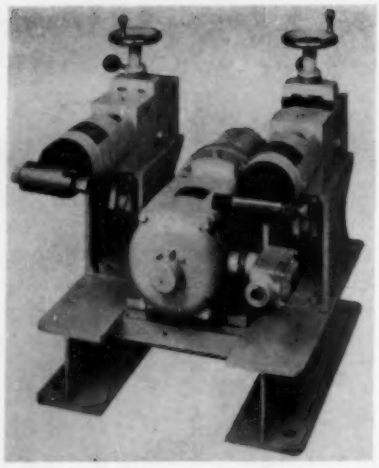
### Dual-trace oscilloscopes hailed as most flexible system yet produced

Two new dual-trace oscilloscopes, Types 1120 Portable and 1120-R Rack-mountable, permit the simultaneous display of two vertical signals against time, against each other (X-Y plots), or versus a third variable fed externally to the X-axis. Considered the most flexible system yet produced for dual-trace oscilloscopes, these main frame indicators have 64 contacts to mate with plug-in circuits. *Analab Instrument Corp.*

Circle number (138) on reply card.

### Unit converts gas chromatographs to flame ionization detection

New high performance flame ionization detector module permits modification of existing gas chromatographs to flame ionization detection. Two inches of insulation may be used between detector burner assembly and the bulk head which terminates connections for hydrogen, combustion air, electrometer, and high voltage connections and flame ignitor. A miniature column connection fitting is connected to the burner assembly. Collector insulation is sapphire to permit high performance operation. *Leo Engineering Co.*



Circle number (139) on reply card.

### Wavelength calibrators offered for infrared spectrophotometers

Wavelength calibrators with a polystyren film in one end that may be inserted into the sample compartment of most infrared spectrophotometers are being offered free by the Scientific and Process Instruments division of Beckman Instruments, Inc. By comparing the spectral curve produced by the film with a polystyrene curve printed on the back of the calibrator, the operator is able to check the instrument for calibration, resolution, and stray light. *Beckman Scientific and Process Instruments.*

Circle number (140) on reply card.

### High-capacity, compact air compressor is introduced

The ER8, new 400-hp stationary air compressor, delivers 2280 cu ft of air per minute at pressures up to 125 psi. Designed for heavy-duty, 3-shift operation, it is a 2-stage, double-acting, water-cooled unit with cylinders placed in "L" arrangement. Accurate balancing and design reduces specific power consumption far below that of the majority of equal size machines. Installation time is minimized, since the compressor is delivered as a complete unit and only requires bolting to a simple steel frame preset in the concrete foundation. *Atlas Copco.*

Circle number (141) on reply card.

### Pumped fluid utilized for cooling, lubrication in new seal-less pump

All lubricating and cooling functions are provided by the pumped fluid in a new seal-less canned motor pump, designated Model 6222 P-15S. Pump is equipped with a welded stainless steel clad rotor and stator, allowing the pumped fluid to pass through the motor air gap. The motor is internally protected with a thermal overload switch. The 15-hp single-stage centrifugal pump develops a 200-ft head at a flow rate of 230 gal per min. *J. C. Carter Co.*

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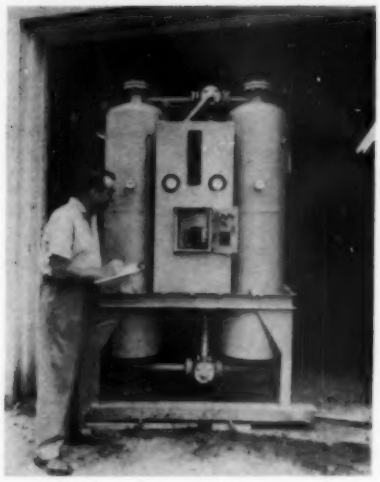
### Dehyditrol unit takes moisture from compressed air, other gases



New gas dehydrating unit, named Dehyditrol, provides complete, continuous, moisture removal through use of twin chambers, each charged with a fixed bed of desiccant. While one chamber is being used for drying, the staurated desiccant in the other is being reactivated. The process is then automatically reversed. The change in direction of the gas, to reverse the roles of the chambers, is accomplished by a quarter turn of the 4-way lubricated plug valves. *Gas Drying, Inc.*

Circle number (143) on reply card.

### Cartridge-type check valve can be placed in single bored hole

The C-200 cartridge check valve is designed to be placed in a single bored hole, thereby avoiding bulky complicated piping arrangements and saving over 75% of the design and installation costs formerly required. Valve is available in steel or aluminum in sizes from ⅛ to ¾ in. and operates at pressures up to 5000 psi. *Circle Seal Products Co., Inc.*

Circle number (144) on reply card.

### Polypropylene plastic fittings stocked for industrial piping

A line of polypropylene plastic fittings for industrial piping is now available in 2 and 4-in. pipe sizes and in Schedule 40 and Schedule 80 wall thickness. Line can be extended readily to cover a complete size range. "Thermo-Seal" homogeneous fusing permits pipe and fittings to be joined quickly and easily, making a leakproof bond that is stronger than the pipe itself and that can be pressurized almost immediately after joining. *Tube Turns Plastics Inc.*

Circle number (145) on reply card.

### Diaphragm relief valve for chemical corrosive service

Super sensitive 1000 Series diaphragm relief valve provides a vapor tight seal to prevent leakage and eliminate waste for chemical corrosive service. Valve's spring and guides are isolated from the process fluid to avoid corrosion problems. Available in wide choice of materials. Sizes include ½, ¾, 1, 1¼, 1½, and 2 in. *Farris Engineering Corporation.*

Circle number (146) on reply card.

### Thermometer clips to pipes, gives surface temperatures

New pipe thermometer clips to steam, water, refrigeration, gas, and other pipes by means of twin spiral spring clips supplied with each instrument. Can be attached or removed from pipes in seconds, and require no alteration of the pipes. Thermometers are precalibrated to counteract possibility of error through heat losses of radiation or convection. Available in two models—No. APFT 460 for temperature range from 32 to 320 F and No. APFT 461 for the colder ranges of −14 to +134 F. *Abrax Instrument Corporation.*

Circle number (147) on reply card.

### Valves feature linear action, 5 to 60 gal per hr capacity

New line of Mod-U-Flo control valves automatically governs flow of non-corrosive liquids with straight-line variations in rate. Made in three sizes, with ratings ranged between 5 and 60 gal per hr. Originally designed for controlling fuel flow to variable-fire oil burner nozzles, but suited to other applications where a reliable, easily-controlled, low-volume modulating valve is wanted. *Hill Machine Company.*

Circle number (148) on reply card.

### Metal deactivator, antioxidant introduced on commercial scale

Two new additives — Metal Deactivator and Antioxidant-ZDP—are now commercially available for use in lubricants and fuels.

Metal Deactivator, which is chemically N, $N^1$ — disalicylidine propylenediamine, is a chelating agent which counteracts the harmful effects of copper on fuels.

Antioxidant-ZDP, which consists of zinc dithiophosphate, also acts as a mild extreme pressure additive when added to lubricating oil, thus protecting engines against cam and lifter wear. *Ethyl Corporation.*

Circle number (149) on reply card.

### Flange adaptor simplifies hose connection problems

New flange adaptor for hose connections is designed primarily to convert any standard gate or special valve of the 150 series in sizes 6, 8, and 12 in. Lugs extending beyond lower lip of adaptor permit the workman to rest the heavy hose flange till it is properly aligned. Use of modified C-clamps attached to adaptor permit a tight joint between flanges. There is no need to align holes or use bolts. *Kerotest Manufacturing Company.*

Circle number (150) on reply card.

### Exchanger line utilizes standard components for custom assemblies

New C-200 straight-tube, fixed-tube-sheet heat exchangers are built from standard, pre-engineered components assembled into custom-built units for specific processing requirements. Use of these components saves substantially in delivery time and offers the user definite cost reductions as compared to conventional tailor-made units. A wide choice of component variation is offered to meet individual operational and environmental specifications. Available in shell sizes from 8 through 42-in. and with any practical tube length. *American-Standard Industrial Division.*

Circle number (151) on reply card.

### It's free! Index covering 1960 issues of Petro/Chem Engineer

Contents of 1960 issues of Petro/Chem Engineer are categorized by subject and author in Petro/Chem Engineer's annual index just off the press. Separate breakdowns for Refining, Petrochemicals, and Gas Processing. Free for the asking. *Petro/Chem Engineer.*

Circle number (152) on reply card.

### Dry acid cleaner, alkalinity-pH depressant added to product line

Two new dry-type chemical treatments, both based on sulfamic acid, have a wide range of application in cleaning boilers, heat exchangers, condensers, evaporators, cooling jackets, process vessels, and piping. They are Alkalinity-pH Depressent 1331 and Dry Acid Cleaner 1332, both of which are available in 50 or 100-lb fiber drums. *Ionic Chemical Co.*

Circle number (153) on reply card.

### Indicating pneumatic controller is offered in improved version

No. 1150 series, improved version of indicating pneumatic controller, incorporates a new non-bleed relay that offers savings in air consumption. Ranges of the pressure model have been extended to 500 psi. Temperature ranges are now available to 1000 F. Other advantages include reduced friction and lower maintenance, the result of simplified design, incorporating fewer pivots in the mechanism. *Robertshaw-Fulton Controls Co.*

Circle number (154) on reply card.

### Atomizing nozzle produces solid cone mist up to 330 gal per hr

Fig. 661-S atomizing nozzle produces a very fine, uniformly-atomized, solid-cone mist in capacities as high as 330 gal per hr. Available from stock in bronze and stainless steel, in orifice sizes from 2.0 to 6.0 mm. Special corrosion-resistant materials also available on request. *Schutte and Koerting Co.*

Circle number (155) on reply card.

### Plastic pump coupling guard offers light weight, corrosion resistance

Pump coupling guard, made from glass reinforced polyester resin or epoxy is corrosion-resistant, strong, and durable. It has approximately a third the weight of steel. Color is blended in the resin, so painting the guards is unnecessary. Four standard sizes are available. *Armadillo Plastics Co.*

Circle number (156) on reply card.

### Units align, support piping in which expansion joints are used

Pipe guides are available in a full range of sizes for aligning and supporting piping in which bellows expansion joints and expansion compensators are used. Units, made of carbon steel, consist of a guide spider, to be clamped around the pipe whose movement is being controlled, and a guide casing, which can be bolted to base or other supporting structures at any angle. There are two standard models: Series A for up to 1½-in. insulation and Series B for up to 2-in. insulation, from ¾ to 30-in. pipe size. Guides for greater insulation thickness can also be supplied. *Tube Turns Division, Chemetron Corporation.*

Circle number (50) on reply card.

### 12-position automatic valve has variety of applications

New 12-position automatic valve can be used for automatic gas sampling and as an automatic sample feed to gas chromatographs or mass spectrographs. The 12 separate intake ports are connected to a common vacuum chamber. Each valve is sealed by a spring loaded valve except at the time the port is open for sampling. In a typical application this valve is used in a plant safety program where air from 12 different locations is connected to one central combustible gas alarm. In this same manner 12 different liquids or gases can be programmed to flow to one central analyzer or tank. *Gelman Instrument Company.*

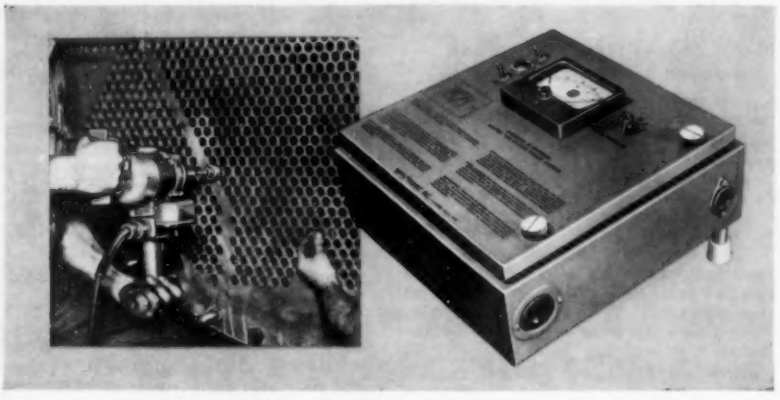
Circle number (51) on reply card.

### Flexibility is key feature of new low-capacity metering pump

Custom metering of a wide range of corrosive liquids is provided by a new low-capacity metering pump available with either single head (Series A-747) or double heads (Series A-748). Maximum capacities are 250 and 500 gal per day respectively, and maximum pressure is 100 psi for both models. Dual-head model has separate stroke-length adjustment and indication for each head. Thus, two chemicals can be proportioned simultaneously, or twice the volume of the single model can be handled with one pump. Maximum capacity per head of 250 gal per day can be reduced to 140, 80, or 40 by simple belt and pulley changes. *Wallace & Tiernan Inc.*

Circle number (52) on reply card.


**Your Motor + Wiedeke Torque Control = Increased Tube Rolling Production**



Save the cost of a new motor! New Torque Control Instrument for rolling ¼" through 4½" tubes in boilers, condensers and similar heat transfer vessels —operates with any Universal Reversible Electric Tube Rolling Tapper or Motor. Adjustable time cycle matches operator's dexterity.

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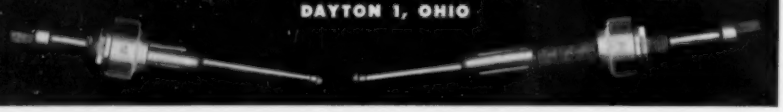


### Thin-film memory makes possible computer operating in nanoseconds

"First of the third generation computers," the Univac 1107 Thin-Film Memory Computer, ranks with the fastest super-scale computer systems ever developed. Time required to retrieve information from computer's internal memory is rated in terms of nanoseconds—billionths of a second. This performance is possible thanks to development of thin magnetic film computer memory, heralded as a major scientific breakthrough in the field of electronic data processing. Computer applications include scientific computation, data and reduction analysis, digital communication and switching systems, tactical data and control systems, and inventory and scheduling systems. *Remington Rand Univac Division, Sperry Rand Corporation.*

Circle number (53) on reply card.

### Refuse container handling unit adds to Dinosaur's versatility

With new Dinomaster unit the Dempster-Dinosaur can be used as a complete system for general refuse collection and disposal as well as for heavy materials handling. The new development, which consists of a compaction body and two cab-clearance lifting arms mounted on a standard Dinosaur frame, can be operated as a self-loading packer when automatically pulled up on the Dinosaur skid frame and locked into place. In operation it approaches a refuse storage container, engages the side channels, lifts it over the cab, and empties the contents into its compaction body, where the material is squeezed to a fraction of its former volume by action of the 60,000-lb thrust of the packer plate. *Dempster Brothers.*

Circle number (54) on reply card.

### Anatrol system makes containers resistant to corrosive chemicals

New Anatrol system is said to make stainless and mild steel containers resistant to such corrosive chemicals as sulfuric, phosphoric, and nitric acids and a variety of strong caustics by electrically depositing and maintaining a protective film on metal surfaces. The system, based on anodic passivation, improves the quality of stored acids and end products by ridding them of metal contaminants. Anatrol, developed by research scientists of Continental Oil Company, consists of a controller, power supply, and electrodes. *Minneapolis-Honeywell Regulator Co.*

Circle number (55) on reply card.

### Systems for overhead, underground piping feature plastic coverings

New prefabricated piping system for overhead distribution of steam, hot water, process liquids and refrigeration lines consists of the pipe and insulation covered with aluminum foil, over which are two wrappings of fiber glass cloth integrated within Plasti-clad material. A final color coat of Plasti-clad is applied to finish the unit. Entire system is factory prefabricated complete with expansion loops, anchor units, elbows, and "T" units ready for installation.

Plastic coated system for underground distribution consists of pipe and insulation covered by a spiral welded metal conduit. Conduit is protected against soil and stray current corrosion by a 20 to 25 mil coating of cold-cured epoxy coating, which is reinforced wtih fiber glass cloth. Coating is resistant to acids, alkalis, and salts; has a high dielectric strength and will withstand a 10,000-v spark test; is resistant to continuous temperatures of 375, and does not crack or cold check at low temperatures. Expansion and contraction of conduit will not rupture the coating. All units are factory prefrabricated in sections as required by job conditions. *Ricwil, Inc.*

Circle number (56) on reply card.

### Miniature filter assembly can be used with caustics, corrosives

New light weight, miniature filter assembly for fluid line systems is applicable where caustic and/or corrosive liquids or gases are being handled and as a filter for instrument and gaging points. Has been in service with gases to 2250 psi and will withstand temperature extremes from —350 to +500 F. Comes in standard sizes to fit ¼ and ⅜-in. tube sizes, with other sizes available on request. Company will also manufacture the assembly to customer specifications. *Dumont Engineering Corp.*

Circle number (57) on reply card.

### Compound lever liquid drainer has large discharge capacity

Model 248 liquid drainer discharges exceptionally large loads of liquids from gases at pressures to 600 psi via high leverage mechanism and an 8-in. diameter stainless steel float. Design will permit opening a ¾-in. orifice at 270 psi or a ½-in. opening at 600 psi. Nine orifice sizes are available ranging from ¼ to ¾-in. Maximum cold water capacity ranges from 14,000 lb per hr at 600 psi with the ¼-in. orifice to 85,000 lb per hr at 270 psi with ¾-in. orifice. *Armstrong Machine Works.*

Circle number (58) on reply card.

### Refinements increase speed, capability of G-20 computer

A 40% increase in computing speed has been achieved with the G-20 computing system and the full-word clock cycle time has been reduced to 6 microseconds. Magnetic tape speeds have been doubled. Both the accessory control buffers and the magnetic tape control units are now equipped with program controlled electronic switches that can connect them to either of two communication lines. Simultaneous data transfers can be made over multiple communication lines in a flexible and efficient manner. *The Bendix Corporation.*

Circle number (59) on reply card.

### Savings in many applications possible with new alloy steel

Significant savings in fabrication of stronger, lighter steel structures and equipment are promised with use of "T-1" Type A, a new low-cost constructional alloy steel available in quenched and tempered plates and bars ranging from 3/16 to 1-in. in thickness. In this thickness range "T-1" Type A has the same 100,000 psi minimum yield strength as "T-1" steel as well as having the same degree of toughness, weldability, and resistance to impact and abrasion. However, Type A costs considerably less because of differences in chemical composition. *United States Steel Corporation.*

Circle number (60) on reply card.

### Cylinder operation available for several types of valves

A universal type cylinder operator has been developed that is adaptable to outside screw and yoke, iron body wedge, or double disc gate valves, and to pulp stock valves. Factory installed valves with cylinders are available, or the cylinders may be had in kit form for rapid in-the-field installation on iron body hand-operated valves already in service. Valves are actuated by a double-acting cylinder, using water, air, or oil as the operating medium. Cylinders are controlled by operation of a 4-way valve, which may be located in any convenient place within reasonable distance from the main valve. *Crane Co.*

Circle number (61) on reply card.

*Specialized EFCO Experience*

**Solves Specific HEAT TRANSFER PROBLEMS...**

Years of experience in engineering and fabricating of heat exchangers for the wide range of temperatures/pressures encountered in refining-petrochemical-natural gasoline plant processes enables EFCO to offer service-proved engineering design and guaranteed job rating. Gulf Oil Corporation is one of many process equipment users who are benefiting from EFCO's specialized experience and engineering efficiency.

This Gulf Oil Corporation installation of Efco units, in Gulf's Port Arthur Refinery, is typical of the many high-pressure, high-temperature exchangers designed and fabricated by EFCO.

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at joint where pipe is screwed into fitting

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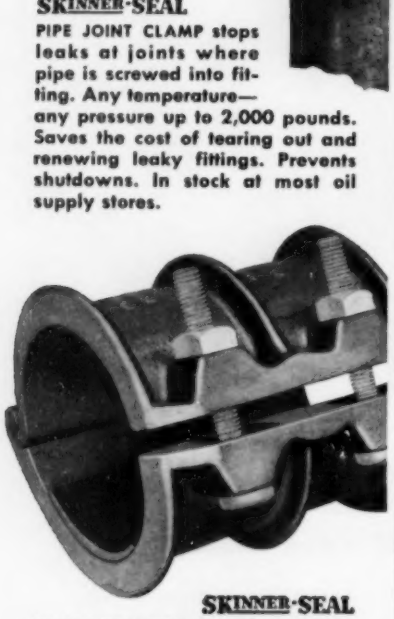

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EMERGENCY PIPE CLAMPS for safe, sure, lasting repair of splits and rust holes in pipe. No pressure too high. Anyone can apply in a few moments. Made in all sizes, ½" to 12", for steel and C.I. pipe. Stocked by practically all oil supply stores.

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# PETRO/CHEM new literature

**Aliphatic amines** . . . what they are and what they will do . . . are subject of new booklet. Tradenamed Armeens, they retain most of the reactivity of ammonia, while the long, normal alkyl groups obtained from their parent fatty acids impart additional desirable properties. *Armour Industrial Chemical Co.*

Circle number (62) on reply card.

**Bitumastic cold-applied protective coatings** . . . for protection against corrosion . . . are described and the recommended coating for various applications given in Bulletin T-97-61. *Koppers Co., Inc.*

Circle number (63) on reply card.

**Blowout proof gasket** . . . the 6400 series Gask-O-Seal . . . is detailed in illustrated data sheet. *Parker Seal Company.*

Circle number (64) on reply card.

**Catalysts** . . . for specific applications can be determined with minimum effort from descriptions in new Catalog GC 2000A, which covers company's entire line of catalysts for gas processes, petroleum, and chemical industries. *Girdler Catalysts.*

Circle number (65) on reply card.

**Cationic and non-ionic surface active agents** . . . ranging from fatty nitrogen derivatives to polyether alcohols . . . are discussed in Bulletin K-6. Physical characteristics of the chemicals and some of their uses are included. *Nalco Chemical Co.*

Circle number (66) on reply card.

**Chemical analysis of tubing steels** . . . standard carbon, alloy, and stainless . . . used for corrosion resistant service or elevated temperature and/or pressure service . . . is shown in Bulletin T-456. *Babcock & Wilcox.*

Circle number (67) on reply card.

**Coagulation chemicals for water treatment** . . . are discussed in Bulletin A-1, which describes application of sodium aluminates; refined montmorillonites; cationic, anionic and non-ionic polymers, and a new concept of "Inline Clarification." *Nalco Chemical Co.*

Circle number (68) on reply card.

**Complete control cabinets** . . . for handling hazardous materials while safeguarding personnel and maintaining material purity . . . are illustrated and described in 24-page catalog. Includes cabinet designs for specific applications as well as variety of component accessories. *Hamilton Manufacturing Company.*

Circle number (69) on reply card.

**Condenser tube handbook** . . . has 10 pages of tables that provide valuable information on corrosion ratings of various condenser tube materials. Also has data on welding installation of tubes and updating of specifications (ASTM B-111) and estimating data for maximum lot weights. *Chase Brass & Copper Co.*

Circle number (70) on reply card.

**Controlled volume pumps** . . . are featured in revised 32-page Bulletin 553-2, which has a selection data guide, materials selection charts, and capacity-pressure selection tables. *Milton Roy Company.*

Circle number (71) on reply card.

**Coupling specifications** . . . are contained in two new bulletins. Catalog 68 deals with rubber-cushioned, sleeve bearing, flexible couplings, while Catalog 69 covers dihedral gear couplings. *Ajax Flexible Coupling Co.*

Circle number (72) on reply card.

**Current-limiting circuit breakers** . . . are detailed in 2-color, 10-page Bulletin 4300-1A that illustrates and describes new K-Don line. *I-T-E Circuit Breaker Co.*

Circle number (73) on reply card.

**Drop-forged steel flange specifications** . . . are detailed in new catalog in which charts give pertinent dimensions such as pipe size, hub diameter, size, number of bolts, etc., to the 150, 300, 400, 600, 900 and 1500-lb flanges. *Harrisburg Steel Co.*

Circle number (74) on reply card.

**Double pipe heat exchanger installation and maintenance instructions** . . . are given in Bulletin 120. *Brown Fintube Co.*

Circle number (75) on reply card.

**Ductile iron gate valves** . . . the Pipe-Pal series of ½ through 2-in. small gate models featuring spiral-wound gaskets and unique "spread flange design," and the Pipe-Mate series of 2 through 12-in. large gate valves incorporating a new and stronger "buttressed flange" construction . . . are described in Product Brochure 1011. *Ohio Injector Co.*

Circle number (76) on reply card.

**Equipment for the process industries** . . . including conveying systems, rotary compressors, coolers and preheaters, blowers, pumps, fans and exhausters, and accessory equipment . . . are described and illustrated in Bulletin G-3D. *Fuller Co.*

Circle number (77) on reply card.

**Float-type liquid drainers** . . . for discharging liquids from gases under pressure to as high as 5500 psig and for capacities up to 30,000 lb per hr . . . are described in new technical bulletin. *Armstrong Machine Works.*

Circle number (78) on reply card.

**Float valve bubble tray** . . . is subject of 12-page brochure that gives mechanical features, operation data. *Nutter Engineering Co.*

Circle number (79) on reply card.

**Gas-fired infra-red burner** . . . designed for low-temperature industrial process heating where heat transfer in the infra-red range is highly effective . . . is subject of Data Sheet 1B-4. Literature contains performance curves as well as data on application, selection, and specification of units. *Bryant Industrial Products Corporation.*

Circle number (80) on reply card.

**"Half a Man Is Not Enough"** . . . is title of new 12-page booklet that discusses the problem of over-specialization by engineers with its resultant lack of development in the fields of human interests and understanding. It points out that human interests must balance technical efficiency for well-rounded successful living. *Western Supply Co.*

Circle number (121) on reply card.

**Handy wall chart** . . . quick reference guide to ASME Boiler and Pressure Vessel Code (Section VIII) . . . illustrates some of the types of pressure vessel construction provided for under this section and furnishes direct references to the code rules that apply to these construction features. *Missouri Boiler & Tank Co.*

Circle number (122) on reply card.

**How to plan industrial power distribution systems** . . . is subject of 48-page Bulletin GEA-7139. Chapters include choosing voltages, short circuit calculations, protective relaying, selection of unit substations, power factor corrections, and grounding. *General Electric Company.*

Circle number (123) on reply card.

**Industrial gas turbine specifications** . . . are given in Bulletin GED-5685, which describes Models 720 and 722. Graphs provide data on operating conditions, duct losses, and torque for units, which produce 1000 hp. *General Electric Company.*

Circle number (124) on reply card.

**Industrial telemetering** . . . is explained simply in new series that starts with the ABC's of land line codes, parity checks, weighted binary techniques, and other basics. It will continue through an entire exposition of supervisory control and telemetering. 69-page first volume now available. *Dresser Electronics.*

Circle number (125) on reply card.

**Industrial wire cloth and screen information** . . . is contained in new loose leaf specification catalog. Included are four bulletins that give technical reference data. *Cleveland Wire Cloth and Manufacturing Company.*

Circle number (126) on reply card.

**Lubricating and servicing instructions for Rockwell-Nordstrom valves** . . . are given in Bulletin V-218 Rev. 2. *Rockwell Manufacturing Co.*

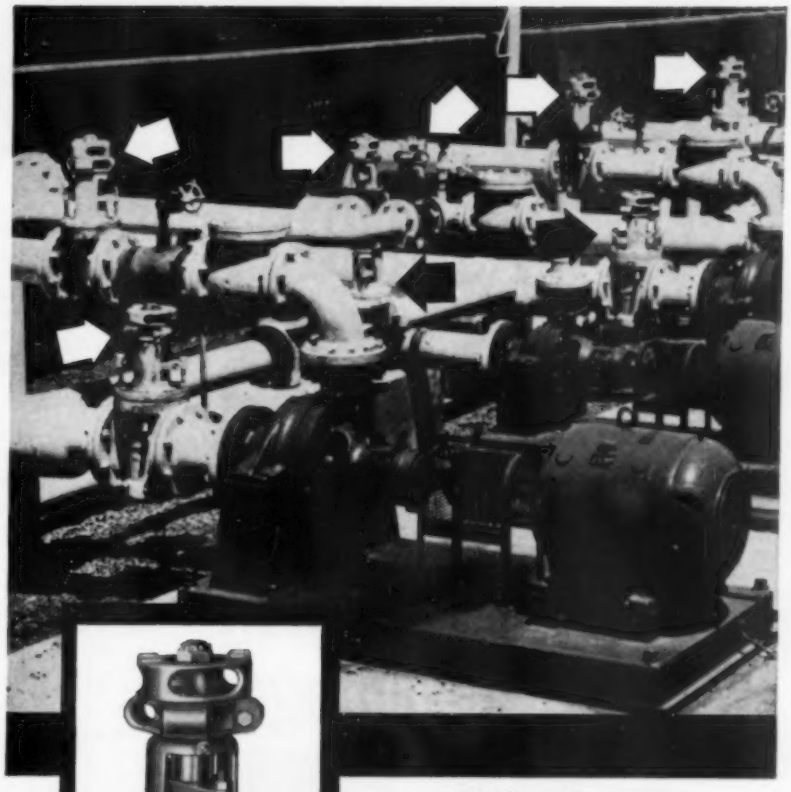
Circle number (127) on reply card.

**Packaged central station air conditioning units** . . . new line that features a complete selection of "Better Air" filters . . . are described in 60-page product bulletin, No. AC-100, making it possible to select the unit, coils, accessories, filters, and even traps, without referring to separate bulletins. *American Air Filter Company.*

Circle number (128) on reply card.

**Packed column support plates, distributors, and hold-down plates** . . . are covered in 32-page Manual TA-40, hailed as first complete design manual on this subject. Discusses such aspects as height of packing above support plates, methods of re-distribution, how to install support plates, and where holddown plates are desirable. Gives average flow in gallons per minute for different types of distributors. *U. S. Stoneware Company.*

Circle number (129) on reply card.

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**Petrochemical industry applications** . . . of the Vibraswitch malfunction detector are explained in Special Report V-103, which cites six specific instances in which these units protected various pieces of equipment and prevented extended down time and/or serious damage. *Robertshaw-Fulton Controls Company.*

Circle number (130) on reply card.

**Portable crude distillation unit** . . . designed to process 200 bbl of crude per day (35 gravity or higher) into gasoline, diesel fuel, and residual fuel oil . . . is explained in new bulletin. *Williams Brothers.*

Circle number (131) on reply card.

**Pretreatment for effective corrosion control** . . . is subject of new water conditioning data sheet that tells how rapid film formation by pretreatment can vastly improve cooling water corrosion control. *Betz Laboratories, Inc.*

Circle number (132) on reply card.

**Process control instruments** . . . including Microsen closed-loop, all-electronic process control systems; capacitance actuated level detection and control instruments, and vibraswitch malfunction detectors . . . are covered in Bulletin 10, which describes functions and applications for individual instruments and groups of instruments. *Robertshaw-Fulton Controls Company.*

Circle number (133) on reply card.

**Process equipment and systems** . . . for size reduction, size classification, mixing and blanding; materials handling systems, pelleting and densifying equipment, and general process equipment . . . are cataloged in Bulletin 200-B. *Sprout-Walden.*

Circle number (134) on reply card.

**Refractors for HPI applications** . . . are subject of data sheet that contains tables on castable refractories, illustrations of a typical refractory anchor arrangement for catalytic cracking units, and information on acid-proof brick, shapes, and floor tile. *Harbison-Walker Refractories Co.*

Circle number (135) on reply card.

**Seamless welding fittings and flanges** . . . in carbon, alloy, and stainless steels . . . are detailed in Bulletin FB-502A. Contains charts of standard sizes and schedules according to ASA B36.10 and ASA B36.19; comprehensive breakdown of dimensional tolerances; chart of sizes and types available. *Babcock & Wilcox.*

Circle number (136) on reply card.


# FLUID & GAS PRESSURE TANKS

## STAINLESS & CARBON STEEL TANKS

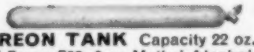
**(GOVERNMENT SURPLUS BARGAINS)**

**Steel tanks for the handling, storage and transportation of gases, beverages, fuels, hydraulic fluids and other liquids. Stainless steel tanks for corrosive acids and gases.**

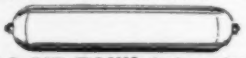
**J-1 PRESSURE TANK** Stainless steel, surplus aircraft oxygen tank. 48" long, 24" dia. Rated for 400 P.S.I. working pressure, 18,000 cu. in. vol., 77.9 gal. capacity. ¼" pipe thread fitting at each end. New condition. Shipping weight 247 lbs. F.O.B. Chicago.
No. AJ832.....$99.50

**G-1 TANK** Stainless steel. Capacity 2100 cu. in. (9 gals.) 450 P.S.I. ¼" pipe thread port at each end. 24" long, 12" dia. Shipping weight 19 lbs. F.O.B. Chicago. (Two for $27.00.)
No. AJ63 Each.....$14.95

**NON-SHATTERABLE $CO_2$ CYLINDER** This type of pressure bottle was used by the Armed Forces for inflating life ratts. 18¼" long, 3¼" dia. Has ⅛" pipe thread opening at one end. Capacity 2.98 lbs. of $CO_2$—at 1800 P.S.I. Shipping weight 10 lbs. F.O.B. Chicago.
No. AJ303.....$2.50



**FREON TANK** Capacity 22 oz. of Freon F22, 6 cc Methyl Alcohol. 18¼" long, 2" dia. ⅜" pipe thread opening at one end. Equipped with brass valve. Shipping weight 3 lbs. F.O.B. Chicago. (Six for $8.00).
No. AJ834 Each.....$1.50



**D-2 AIR TANK** Carbon steel. Capacity 500 cu. in. (approx. 2 gals.) 450 P.S.I. ¼" pipe thread port at each end. 24" long, 6" dia. Postpaid. (Two for $8.50).
No. AJ391 Each.....$4.95

**CORNELIUS HIGH PRESSURE (1500-2000 P.S.I.) AIR COMPRESSOR** Three cylinder, 3-stage compressor, complete with 27 volt, D.C. 20 amp. motor, with fan. Rated 1500 P.S.I. continuous duty, 2000 P.S.I. intermittent. Pressure switch in base. As released by Air Force, in used, serviceable condition. Covered by our 30 day GUARANTEE. 11½" long, 7" high, 9" wide. Shipping weight 12 lbs. F.O.B. Chicago. Limited quantity.
No. AJ549.....$35.00

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# GROBAN SUPPLY COMPANY

1139 SOUTH WABASH AVE., DEPT. AJ-2, CHICAGO 5, ILL., WEbster 9-3793

# PETRO/CHEM newsmakers

▸ **Paul D. Meek** has been named head of the new chemical department formed by Cosden Petroleum Corporation. Meek, who previously was manager of the technical department, joined Cosden in 1955 as a process engineer and later became head of the process design group.

▸ Signal Oil and Gas Company has named **S. A. Patterson** assistant general manager of the manufacturing department. Patterson, who is a vice president, has been in charge of the company's economic development department since early in 1960.

▸ Key El Paso Natural Gas Products Company appointments:

**Jack H. Riddle,** division engineer responsible for all engineering at the Odessa, Texas, complex.

**James H. Pepin,** plant engineer at the Ciniza refinery, where he will be responsible for all phases of engineering at the new refinery in northeastern New Mexico.

**George Harrison,** now maintenance superintendent at the Ciniza refinery.

▸ **Raymond C. Lepley** has been named director of the technical service evaluation and budget division of The Atlantic Refining Company's manufacturing department.

▸ Now manager of foreign projects for the refinery division of Arthur G. McKee & Company is **William J. Funk.** He will be responsible for coordinating engineering, purchasing, inspection, and construction of foreign petroleum projects except those in Canada and Mexico.

▸ Sun Oil Company announces appointments of:

**Marlin P. Nelson,** assistant director of the advanced management and methods division.

**Dr. William E. Bonnet,** manager, economics and planning, in the recently organized commercial development division of the research and engineering department.

▸ **Clark P. Lattin Jr.** has been elected vice president in charge of petroleum and petrochemical development for Chemical Construction Corporation. He is a former vice president of Foster Wheeler Corporation.

▸ **R. E. Howe,** executive vice president of Sinclair Refining Company, has been elected a director of the Western Petroleum Refiners Association. He will fill the unexpired term of **T. B. Kimball,** former president of Sinclair Refining Company, who recently was named executive vice president of Sinclair Oil Corporation.

▸ Recent engineering appointments at Humble's Baytown, Texas, refinery:

**H. K. Arnold** and **M. Rosenbaum,** senior chemical engineers in technical division.

**P. A. Ostermayer,** staff engineer, process technical division.

**C. V. McKean,** staff engineer, technical division.

▸ **Dallas R. Lamont** has been elected to succeed **Arthur V. Danner** as senior vice president in charge of research and engineering of Socony Mobil Oil Company, Inc. Lamont formerly was vice president of research. Danner has become president of Mobil Petroleum Company, a new operating division responsible for Mobil's business interests in the Far East, Australasia, and Eastern and Southern Africa.

▸ **Elwood I. Clapp Jr.,** technical economist, **Bernard J. Williams,** mechanical engineer, and **Charles J. Paulus,** plant engineer, have joined SunOlin Chemical Company and will assist with technical economics and with design and maintenance procedures for the $20,000,000 ethylene and ethylene oxide plant under construction at Claymont, Delaware.

▸ Gulf has advanced **Dr. Jerry McAfee** to the newly created office of vice president-technical advisor. He formerly was vice president-engineering for the manufacturing department.

▸ **Dr. David K. Roe** has joined the scientific staff of Shell Development Company's Emeryville, California, research center as a chemist in the materials engineering and corrosion department.

CIRCLE SEAL MANIFOLD VALVE...

3 VALVES IN ONE ...COMPACT ...LEAKPROOF

Completely positive sealing to 2000 psi.
Reduces installation costs.
Available in brass or 303 stainless.

Specifically designed for use with differential type measuring, recording or transmitting instruments in refinery, petrochemical plants, pilot plants, test labs and research labs.

Complete absence of cross port leakage provides reliable, accurate instrument readings. Because of the three valves designed into one compact body... two tees, four nipples and eight threaded connections are entirely eliminated with resultant cost savings.

The P-727 does not require valve seat replacements and no operating adjustments are necessary.

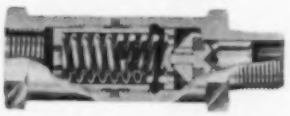
One variation provides a bleed hole to vent both instrument ports when balancing valve is open. Another variation replaces basic five valve assembly.

CIRCLE SEAL PRODUCTS CO., INC.
2181 East Foothill Blvd.,
Pasadena, Calif.

CIRCLE SEAL
precision valves

CIRCLE SEAL

5100 SERIES



IN-LINE RELIEF

Pressure relief valve for non-corrosive and many corrosive fluids. Cracking pressures from 10 to 2400 PSI, adjustable 10% above and below nominal spring value. Sizes from ⅛" to 1-inch. Many sizes in Texas stock.

SOLENOID VALVES

Bronze, stainless steel, or iron bodies for handling air, oil, water, or chemicals. Sizes from ¼ inch to 3 inches. 3-way and 4-way valves are also available. Many sizes carried in Texas stock.

*Write for literature and prices on the above valves*

*Texas Stocking Representative*

WOMACK MACHINE SUPPLY

DALLAS 2010 Shea Rd. Phone FL 7-3871
TWX DL-1173

HOUSTON 4111 Dennis Phone CA 7-3388




FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

# PETRO/CHEM processing parade

**THERMCO, Inc.,** a new company to design and fabricate process heat transfer equipment for the petroleum, petrochemical, and atomic energy industries, has been formed at Tulsa by William H. Mason, John J. Griffin, and Edwin H. Stabert.

**Yuba International Corporation,** a subsidiary of Yuba Consolidated Industries, Inc., has been formed to develop and control international activities of all divisions and subsidiaries of parent company.

**Universal Oil Products Company,** Des Plaines, Illinois, has purchased Catalytic Combustion Corporation, Detroit, manufacturer of catalytic oxidation equipment for industrial heating applications and for elimination of industrial sources of air pollution.

**Chase Brass & Copper Co.,** Waterbury, Connecticut, a subsidiary of Kennecott Copper Corp., has established a condenser tube clinic to work with various companies on analysis of water, tube failures, corrosion problems, and metallurgy.

CHECK THESE
FACTS
*on the World's Newest, All-In-One Coupling*

for making hose connections at dockside, shipboard, storage depots, off-shore rigs, bunkering stations, and with road and rail tankers, etc.*

✓ **SAFE** Eliminates gaskets, drifts and wrenches and the dangers associated with their use.

✓ **EASY TO OPERATE** Just hook up and rotate the handle.

✓ **VERSATILE** Can be easily adjusted to accommodate the variations found in foreign counterparts of American flanges; can be attached to the hose either by screwing directly to the threaded nipple in the hose or by bolting to an existing hose flange.

✓ **POSITIVE SEALING** The seal is automatically made as the flanges are brought together and even on the roughest surfaces, the *higher* the pressure, the *tighter* the seal.

✓ **POSITIVE LOCKING** The coupling is locked whenever handle rotation is stopped.

**To check ALL the facts on construction and operation, request on your letterhead: "QD-16 Coupling Brochure"*

**Flight Refueling, Inc.**

COMMERCIAL PRODUCTS SECTION BOX 1701 BALTO. 3, MD.


**Rockwell Manufacturing Company** has opened newly expanded and modernized chemical engineering research laboratories adjacent to the main headquarters building, Pittsburgh.

**Tretolite Company of California** division of Petrolite Corporation has moved from Los Angeles to new offices and manufacturing plant at 200 South Puente Street, Brea, California.

**Shand and Jurs Company,** Berkeley, California, and Whessoe Ltd., Darlington, England, have extended their agreement giving Whessoe exclusive rights to manufacture and sell S&J products, which include tank fittings and telemetering equipment, within the European Common Market.

**Lightnin Mixers, Ltd.,** has been formed in Poynton, Cheshire, England, to manufacture and distribute Lightnin industrial mixers in the European market. New company is joint venture of Mixing Equipment Company, Inc., Rochester, New York, and Stockdale Engineering Company in England.

**Petro-Automation Industries Limited,** headquarters in Calgary, Alberta, is now located at 122 Eleventh Avenue S.W. Company makes automation equipment for the petroleum industry in Western Canada.

## Appointments:

**Ethyl Corporation,** Robert J. Riggs, foreign sales representative in export sales, with headquarters in New York.

**Badger N. V.,** Dutch affiliate of Badger Manufacturing Company, George de Henau, executive sales engineer to the petroleum industry in Western Europe.

**Rockwell Manufacturing Company,** meter and valve division, Roy R. Bush, sales vice president, with headquarters in Pittsburgh.

**Solar Aircraft Company,** Paul A. Pitt, vice president-engineering.

**Fischer & Porter Company,** Lawrence R. Greenhaus, general sales manager; Reginald D. Schuler, director of technology; Manuel J. Kauffman, manager, flowmeter division.

**Wolverine Tube,** division of Calumet & Hecla, Inc., A. E. Nash, director of operations.

**Western Supply Company,** Roger C. Clark, sales representative for Oklahoma, based in Tulsa.

**Lion Oil Company**, division of Monsanto Chemical Company, King B. Burton, assistant manager of gasoline and fuel oil sales, headquartered at El Dorado, Arkansas.

**Robertshaw-Fulton Controls Company,** Robert L. Wehrli, vice president and assistant to the president, with headquarters at Richmond, Virginia.

**Jefferson Chemical Company,** R. V. Boyce, sales manager, West Coast sales district.

**Diamond Alkali Company,** Stanley B. Honour, sales manager, international division, headquartered in New York.

**Cooper-Bessemer Corporation,** William B. Boyum, manager of gas turbine sales.

**Crane Co.,** industrial products group, J. L. Huss, manager of customer distribution service.

**Chipley and Jensen, Inc.,** Milwaukee, Wisconsin, exclusive sales representative in area for Daniel Orifice Fitting Company.

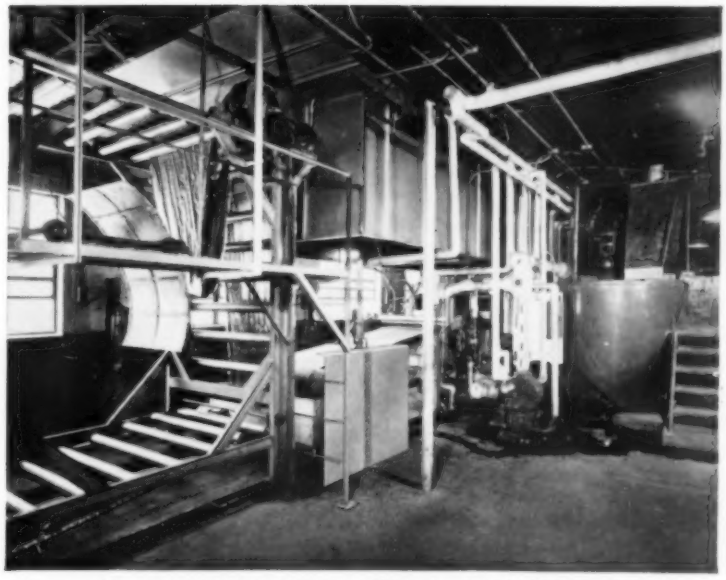
# Introducing TAPECOAT® 20

(Exploded View)

## A Coal Tar TAPECOATing that Provides Single-Wrap Protection **PLUS** an Outer Wrap

- ★ It's more than just a coal tar coating!
- ★ It's designed for single-thickness application!
- ★ It has advanced features of uniformity!
- ★ It assures greater coverage!
- ★ It includes a tough outer wrapper!
- ★ It combines 20 years of manufacturing and field application experience!
- ★ It gives superior protection with greater economy!

*Write for the complete details today.*



View of specially-designed machine developed after five years of research by Tapecoat engineers to convert raw materials automatically into TAPECOAT 20.

## The TAPECOAT Company

ORIGINATORS OF COAL TAR COATING IN TAPE FORM

1567 Lyons Street, Evanston, Illinois

*Telephone: DAvis 8-5220*

**Sales and Service Offices in** New York, Pittsburgh, Charlotte, Birmingham, Houston, Lincoln, Tulsa, Minneapolis, Salt Lake City, San Francisco, Los Angeles, Seattle

New Barber-Greene 7′ Wheel Ditcher crowds through rugged caliche in Texas—at speeds many times greater than ladder ditchers or back hoes working in the area. Write for details.

# NEW 7-FOOT WHEEL DITCHER

## digs more ditch . . . deeper ditch than any machine in its size range

Barber-Greene's new 7′ wheel ditcher offers more ditch for the money than ever before. It digs deeper than any wheel ditcher in its size and price range.

**Check these advantages:**

**Advanced design.** Greater maneuverability—smaller, more compact than other wheel ditchers digging to 7′. The only wheel ditcher available with point of balance at center of tracks.

**Costs less to operate**—exclusive Barber-Greene design advantages add up to more ditch per day with less maintenance . . . less down time . . . less wear.

**Full range of crowding speeds**—exclusive Barber-Greene Hydra-Crowd provides infinite range of crowding speeds . . . permits top digging capacity in all conditions.

**Easier to operate**—full hydraulic controls within easy reach means less operator fatigue . . . easiest steering . . . greater accuracy.

**All-hydraulic spoil conveyor**—10′ variable-speed conveyor loads directly into trucks . . . handles spoil at speeds to 640 fpm. Folds to 8′. Rubber impact rollers reduce belt wear, eliminate material build-up beneath belt.

**New, compact size**—only 26′5″ long, 8′6″ high in operating position. 7′ wide across tracks.

*Manufacturer of the only modern ditcher line*

Representatives in Principal Cities of the World

**Barber-Greene** BG

Main Office and Plant AURORA, ILLINOIS, U. S. A.
Other Plants: DeKalb, Milwaukee, Detroit, Canada, England, Brazil, Australia

CONVEYORS • LOADERS • DITCHERS • ASPHALT PAVING EQUIPMENT



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# SOMASTIC®

## Low-Cost Permanent Pipeline Protection

This is Somastic. It has high dielectric resistance and is moisture proof. It has tensile strength to meet severe soil stresses and depression forces. It has outstanding resistance to corrosive soils. Somastic is without question the finest pipeline protection available today.

Somastic provides lowest cost protection in both difficult and normal exposures because it gives virtually permanent protection.

Write for data giving complete facts on the advantages of Somastic.

**PIPE LININGS Inc.**

Subsidiary of American Pipe and Construction Co.

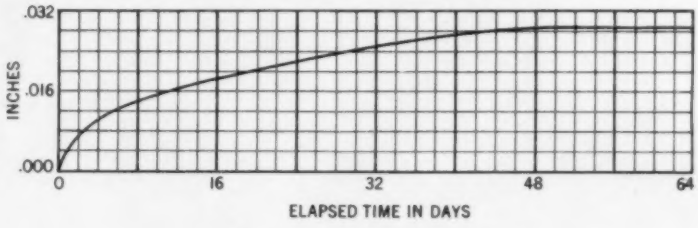
2414 East 223rd Street, Wilmington, California
P.O. Box 457 • Phones: SPruce 5-3273 — TErminal 5-8201
Rail Address, Pacific Electric, Watson, California

# NEWS FROM DOWN THE LINE!

## *Are all pipeline insulators as alike as two peas in a pod?*

They're not alike, not in physical properties! When plastic insulators first became available for pipeline use, WmSON felt they were inferior to the steel and block types then available. We delayed our entry into the field until we could provide a plastic material to withstand field abuse and wear. We found that material in a high density polyethylene which could be injection molded to provide low cost insulators of the highest quality.

Our decision has proved sound. Breakage and excessive wear of glass fibre reinforced plastics, particularly in large sizes, has created a lack of confidence in plastics in general, but the M-2 Plastic THINsulator® has proved its stamina. Its high resistance to cold flow has been proved. Deflection test results: 1000 p.s.i. on each THINsulator runner for 64 days — total cumulative deflection only 0.029". Max. temp. during test, 105° F., min. temp., 75° F.




Its low coefficient of friction causes it to slide easily inside casing. The M-2 is completely resistant to impact fracture (4.0 ft. lbs./in. notched) and has successfully worked on 36" pipe, ½" wall, pulled in excess of 500 feet. We are convinced that it will perform as well or better than any other insulator on the market, including all known steel types. Other physical properties: *Dielectric strength* — (short time, ⅛" thickness) 500 volts per .001 inches (D149-55T); *Tensile strength* — 4400 p.s.i. at 20 in./min.; *Elongation* — 25% 20 in./min.; *Abrasion resistance* — Taber index 5.7.

The increased acceptance of the M-2 THINsulator has brought production to a level of real economy in injection molding. These cost savings are being reflected in new WmSON prices for 1961.

***In planning '61 cased crossings, don't pay a premium for other insulators — use WmSON engineered M-2's and save!***

**T.D. Williamson, Inc.**

P. O. BOX 40 • TULSA 2, OKLAHOMA

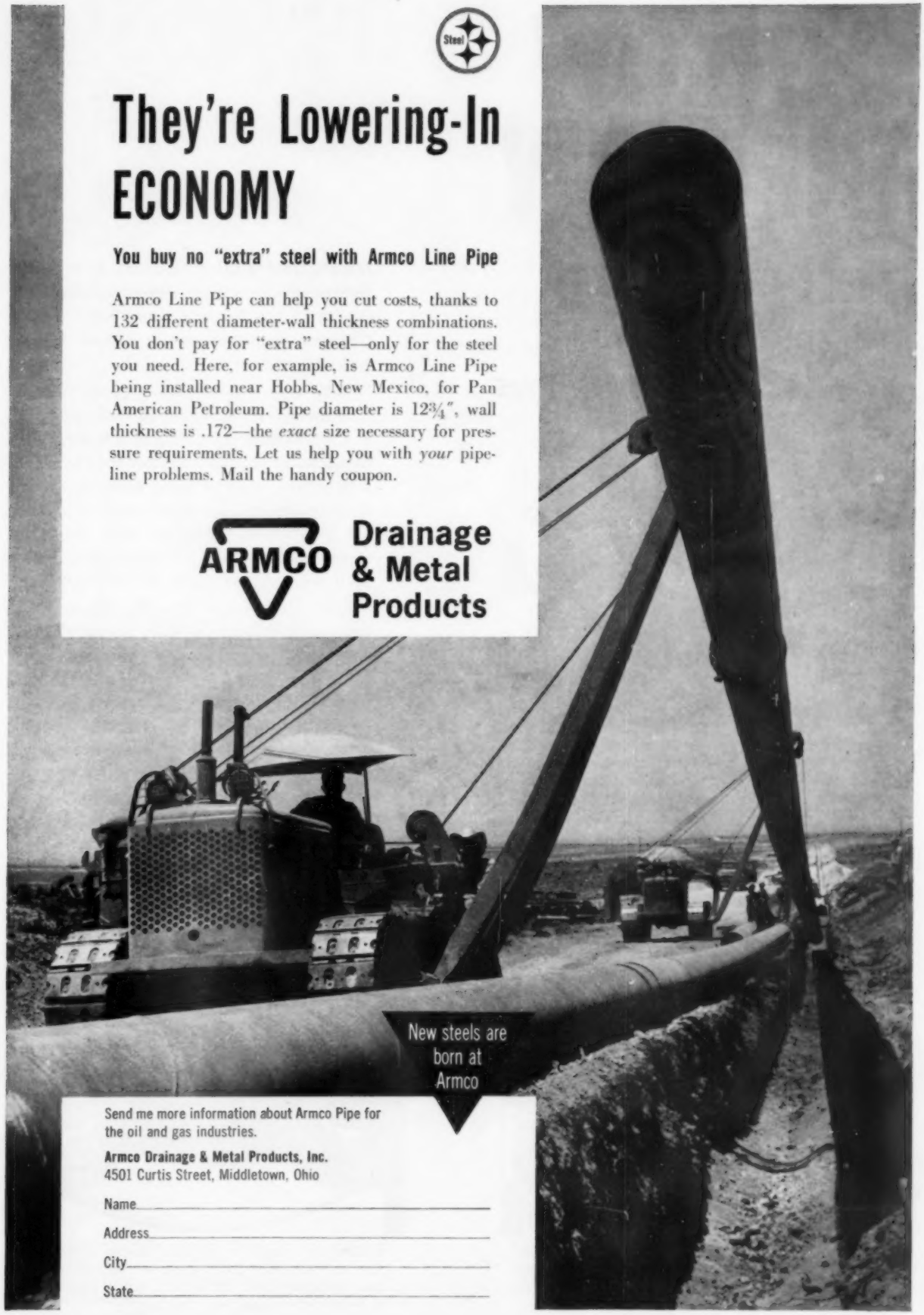
REPRESENTATIVES AROUND THE WORLD

# They're Lowering-In ECONOMY

**You buy no "extra" steel with Armco Line Pipe**

Armco Line Pipe can help you cut costs, thanks to 132 different diameter-wall thickness combinations. You don't pay for "extra" steel—only for the steel you need. Here, for example, is Armco Line Pipe being installed near Hobbs, New Mexico, for Pan American Petroleum. Pipe diameter is 12¾", wall thickness is .172—the *exact* size necessary for pressure requirements. Let us help you with *your* pipeline problems. Mail the handy coupon.

ARMCO **Drainage & Metal Products**




Send me more information about Armco Pipe for the oil and gas industries.

**Armco Drainage & Metal Products, Inc.**
4501 Curtis Street, Middletown, Ohio

Name_____

Address_____

City_____

State_____

# FOLLOW THE FLOW

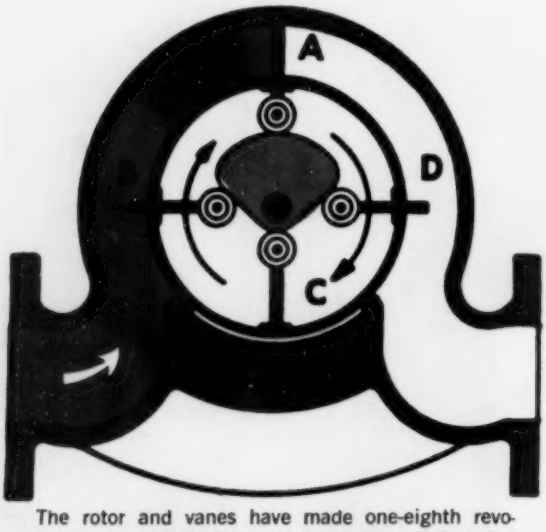
## THAT LEADS TO ACCURATE, TROUBLE-FREE METERING

Unmeasured liquid (dark green) is shown entering meter. Rotor and vanes are turning clockwise. Vanes A and D are fully extended, forming the measuring chamber. Vanes B and C retracted.

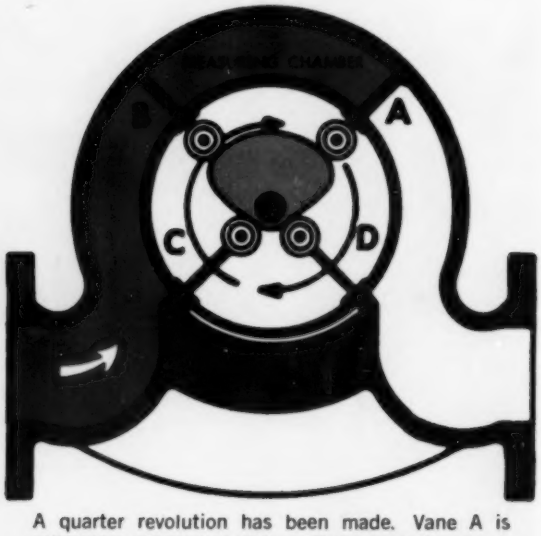
*It's a matter of principle* — the A. O. Smith Rotary Positive Displacement principle that results in the *simplest*, most *accurate* and *trouble-free* metering ever devised for petroleum products.

Let's take a look inside a typical Smith-Erie meter. What we see in these diagrams is a mechanism consisting of a free-running balanced rotor which carries four symmetrical vanes. As the rotor revolves on ball bearings around a central shaft, the vanes are positioned — moving with the fluid stream and dividing it into precisely measured segments of equal and exact volume.

Looks *simple* and it is. Frictional resistance is almost completely eliminated. Flow pattern is smooth and offers no resistance to streamlined flow. *Accuracy?* It's the most! Records show a consistent ability to retain accuracy for the longest periods of time, throughout the greatest flow range. And it's virtually *trouble-free*. Low pressure drop saves power and prolongs service




The rotor and vanes have made one-eighth revolution. Vane A is fully extended; Vane D is being drawn back; Vane C is fully recessed; Vane B is being extended.




A quarter revolution has been made. Vane A is still fully extended and Vane B is now fully moved out. An exact and known volume of new liquid is now in the measuring chamber.



FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

life. Rotor speeds are held within conservative limits to assure long life and freedom from wear.

With such a simple, positive operating mechanism, it's no wonder Smith-Erie meters can be depended upon to provide uniformly high accuracy — day after day and year after year — under the most exacting service requirements.

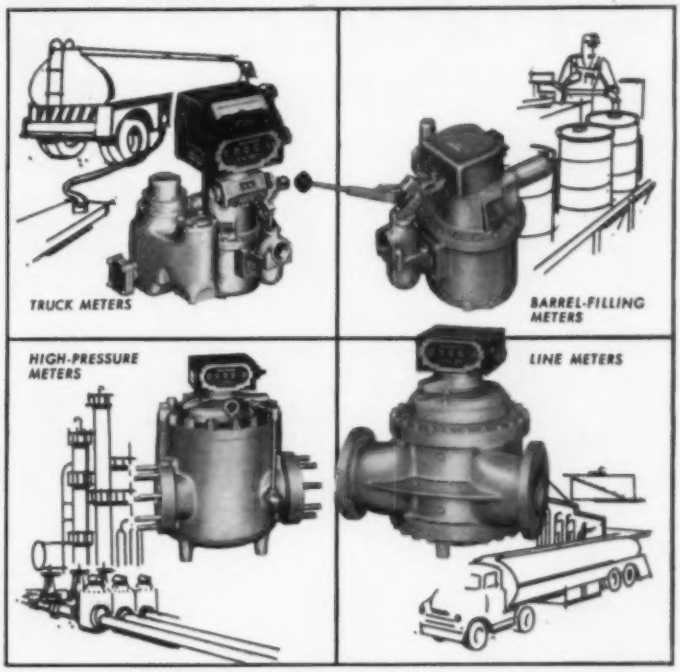
*Through research* ... *a better way*

**A.O.Smith**
CORPORATION

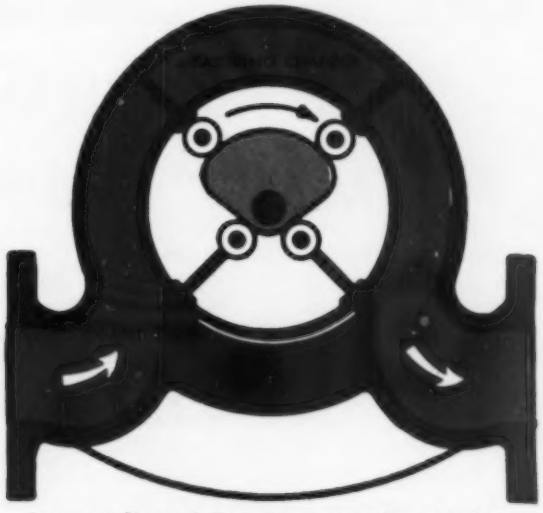
**Smith-Erie Division**

Factory: 1602 Wagner Ave., Erie, Pennsylvania. Offices: Atlanta 5, Ga.; Chicago 3, Ill.; Houston 2, Texas; Los Angeles 22, Calif.; New York 17, N.Y.; Newark, Calif.; Tulsa, Okla. Canada: Toronto 12, Vancouver 1. A. O. Smith INTERNATIONAL S.A., Milwaukee 1, Wis., U.S.A.

## Rotary Positive Displacement Principle Is the Heart of All Smith-Erie Meters

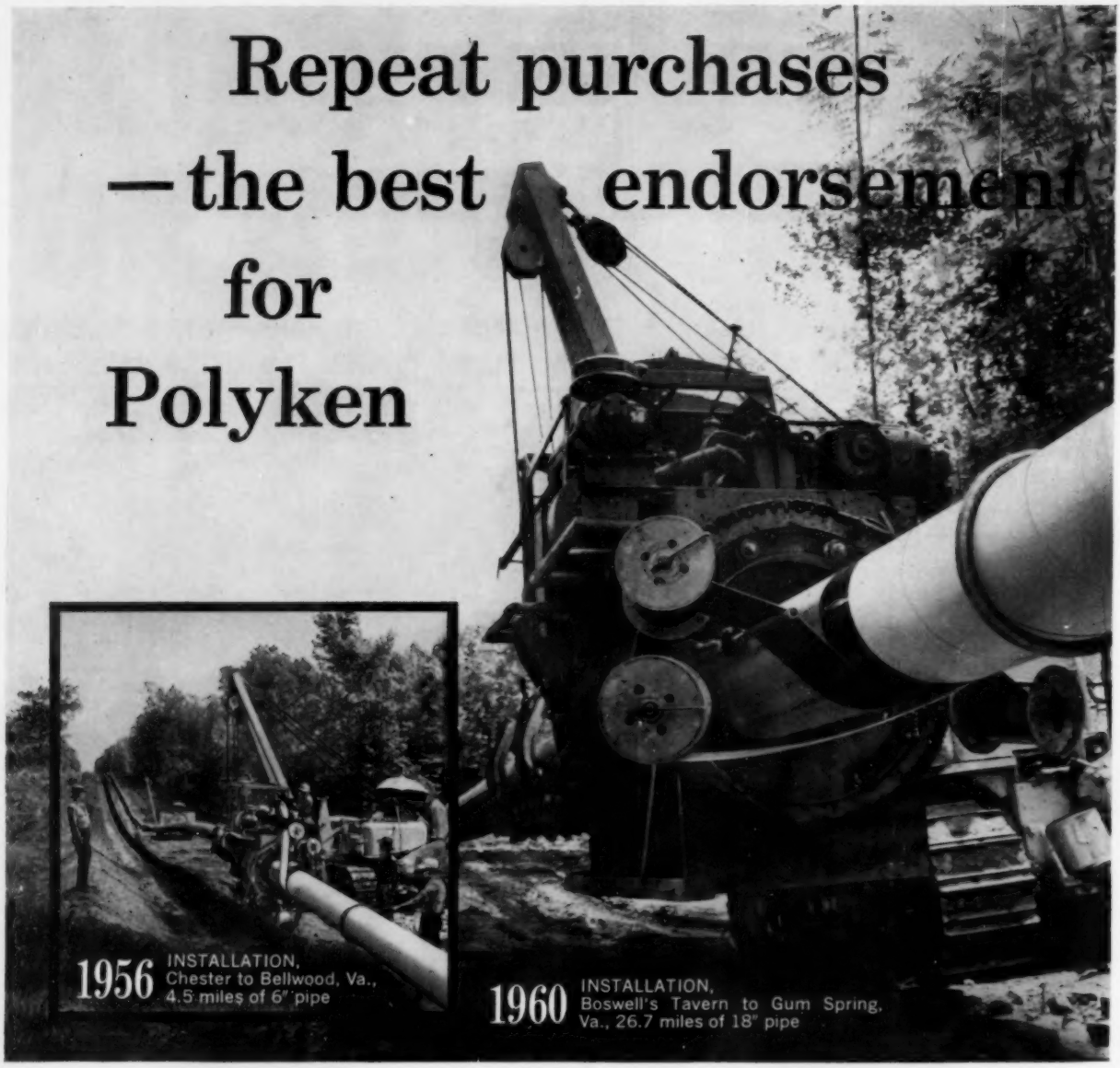


One-eighth revolution later, the measured liquid is moving out. A second measuring chamber is beginning to form between Vanes C and B. Vane A is being drawn back.



In one-half revolution, two measuring chambers have formed and the third is forming. This cycle is repeated as long as liquid flows.

# Repeat purchases —the best endorsement for Polyken



1956 INSTALLATION, Chester to Bellwood, Va., 4.5 miles of 6" pipe

1960 INSTALLATION, Boswell's Tavern to Gum Spring, Va., 26.7 miles of 18" pipe

## Commonwealth Natural Gas makes repeated use of Polyken® tape on strength of past performance

Officials of Commonwealth Natural Gas Corporation of Richmond, Va., were impressed in 1956 with the many advantages of Polyken protection. With confidence based on the cathodic protection needs of their Polyken tape-coated 1956 Bellwood line (*inset photo*), they put this coating to work two years later on their Chester to Petersburg, Va., line (12 miles of 18" pipe). In 1959, *more* Polyken coating . . . Waverly to Ivor, Va., (15.8 miles of 12" pipe). And most recently, the line from Boswell's Tavern to Gum Spring (*main illus.*).

It stands to reason that repeated use is founded on first-hand satisfaction and trust. Many discriminating companies make Polyken protection their standard specification because of its dependable performance. Get full details on Polyken performance and economy from your representative, or write Polyken Sales Division, 309 West Jackson Boulevard, Chicago 6, Illinois.

**Polyken**

EXPERIENCED IN PROTECTIVE COATINGS

THE KENDALL COMPANY
Polyken Sales Division

# Are your costs too HIGH?

## These pipeliners are cutting costs – using SIE control systems

**DISPATCHERS CONSOLE used by Cherokee Pipe Line Company for automatic control of liquid line.**

SIEMARC Supervisory Systems provide automatic monitoring and remote control for many industrial operations and processes including the petroleum installation pictured. Measuring, data gathering, telemetering, logging, display, indicating and computing are all integrated in the system. Both solid-state and relay components are used as dictated by proper engineering design. Transistors and semiconductor diodes are utilized in all high-speed switching and logic circuits including encoders, decoders, analog-to-digital converters, deviation detectors and magnetic drum circuitry. Separate electric logging typewriters record data and alarms.

**POWER LEVEL CONTROLLER used by Shell Pipe Line Corp. Ozark System for maximum pumping station operating economy.**

Completely unattended operation of a multi-unit pumping station is possible with Power Level Controllers used by Shell Pipe Line Corp. The unit accepts signals from flow and pressure pickups and makes logic decisions to bring proper combinations of pump units on or off stream automatically. It may be connected to the supervisory control system to permit reset of power levels from a central office dispatching console.

**COMPRESSOR STATION CONTROL CONSOLE including complete engine control equipment for automatic station operation and safety.**

For gas transmission automation, the basic SIEMARC system can be coupled with Log-Alarm Shutdown and Engine Control-Sequence units. Building block design throughout allows SIE to fit your needs exactly.

**DISPATCH PANEL used by Colorado Interstate Gas Company.**

In the Colorado Interstate Gas Company installation shown, dispatchers transmit only desired discharge pressure settings; automation at each compressor station responds by maintaining the selected value for optimum station economy. If communication links fail, local automation operates without interruption. Log-Alarm units insure station safety. Dispatchers are alerted only when trouble occurs.

*Pioneers in solid state systems for supervisory control and telemetering.*

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Call: SUnset 2-2083
Houston, Texas

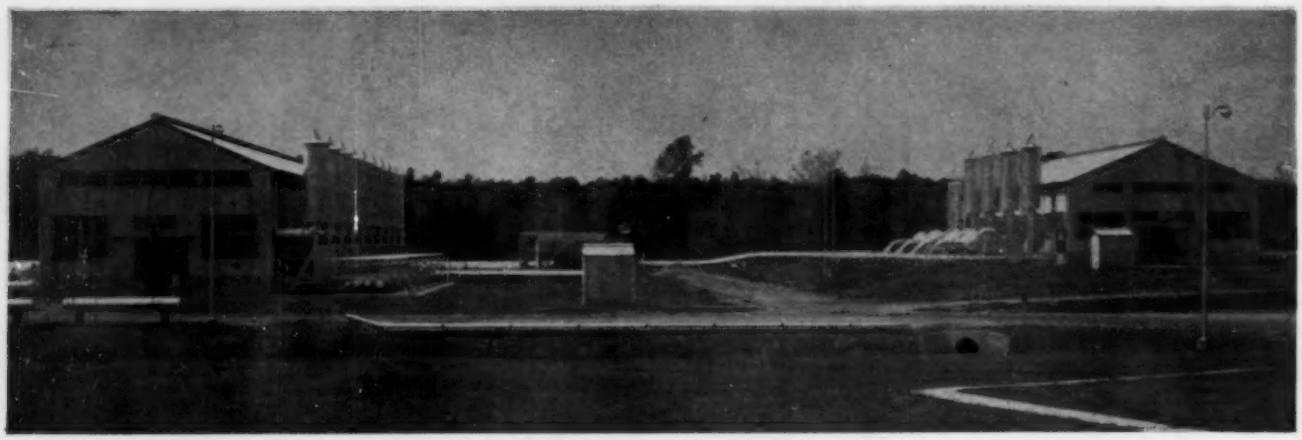
**DRESSER ELECTRONICS**

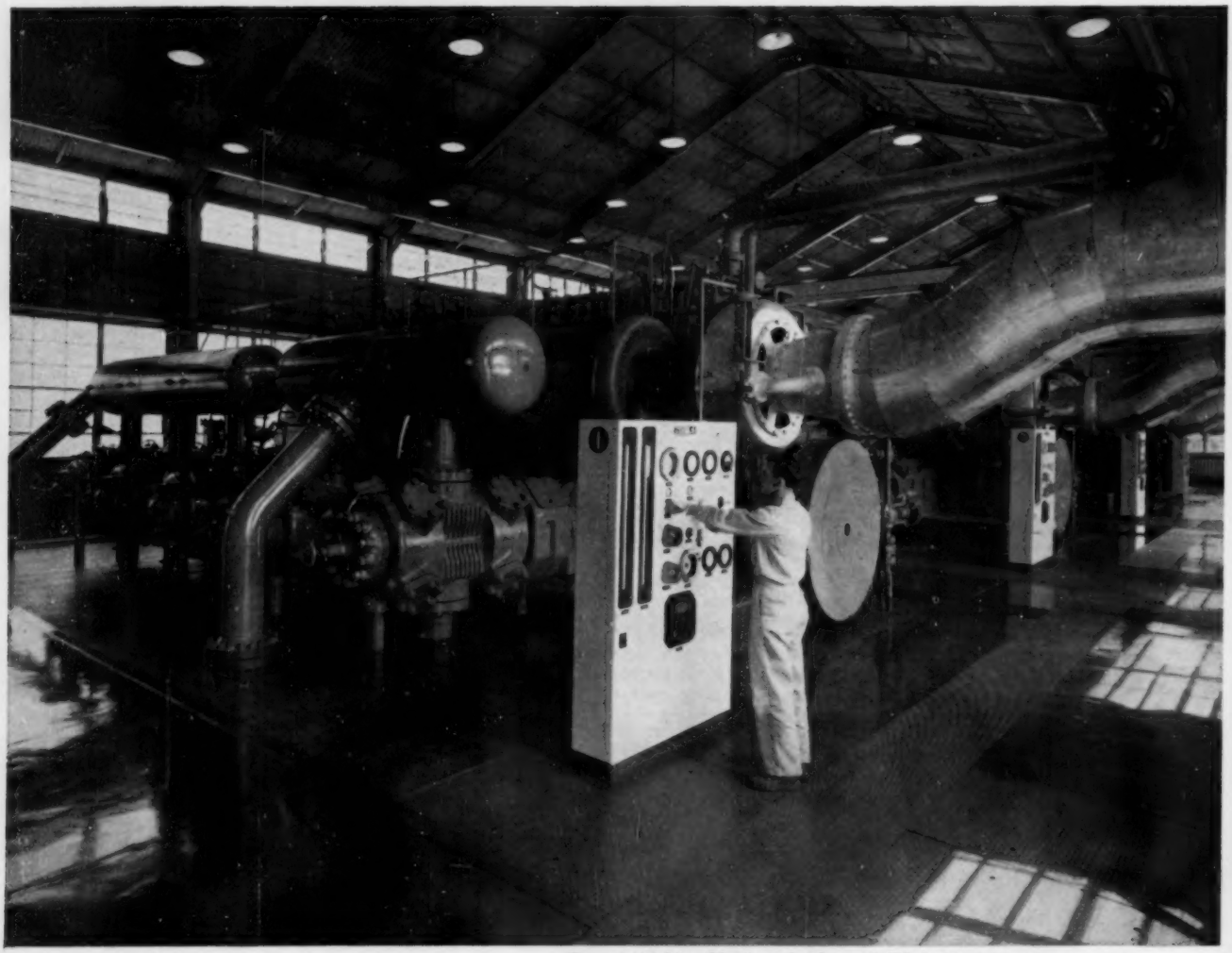
**SIE DIVISION** ONE OF THE DRESSER INDUSTRIES

*10201 Westheimer, Houston 42, Texas*

The first volume in a series on how SIE handles supervisory control and automation for the petroleum industry is now available. The booklet gives the ABC's of land line codes, binary techniques — and many more of the basics. A letter brings you "The ABC's of Industrial Telemetering."

*Union Church, Mississippi compressor station of Texas Eastern Transmission Corporation, as it looks today. Nine Clark HBA-8-T turbocharged units totaling 18,450 bhp are housed at left. Four 3400 bhp Clark turbocharged TLA-10 compressors are in adjacent building at the right in photo. Total Clark horsepower now in station – 32,050 bhp.*





*Four 3400 bhp Clark turbocharged TLA-10 compressors on the Texas Eastern line at Union Church station. Operator is shown at Clark automatic engine starting panel.*



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# "HORSEPOWER TRIPLED, EFFICIENCY VASTLY IMPROVED, MAIN LINE FLEXIBILITY MAINTAINED,"

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In one of their programs, nine existing Clark HBA-8 compressors were converted to turbocharged operation. This was accomplished with the standard Clark conversion kits, thereby increasing the rating of each unit from 1760 to 2050 bhp while at the same time substantially reducing fuel consumption.

To further increase the horsepower of the station, four Clark turbocharged 3400 bhp Model TLA-10 compressors were installed, thus bringing total installed horsepower at Union Church up to 32,050.

The new TLA-10's gave Texas Eastern the positive dollar saving advantage of large blocks of horsepower which users have found results in lower installed and operating costs per bhp. Another important benefit of installing TLA-10's was the ability of these compressors to operate at compression ratios of 1.275 to 2.0. This is a vitally important factor in obtaining maximum operational flexibilty and expandability for future development.

Pipeline operators have found that the special low ratio pipeline compressor cylinders and Clark low loss nylon poppet valves used on the TLA-10 assure highest compression efficiency at a wide range of ratios. The constant pressure, pure turbocharging system used on the TLA, HBA-T and the new TBA permits operation of these units over a wide range of constant torque speeds at utmost fuel economy over the entire range. The Clark System of turbocharging also assures ample reserve *power* for emergency overloads, and traditional Clark ruggedness means the *stamina* is there to handle it.

There are four models of Clark TLA compressors available in the 1700-3400 bhp range and four models of TBA compressors available in the 1500-3000 bhp range. Your local Clark representative will gladly give you all the facts.

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**NOTE:**
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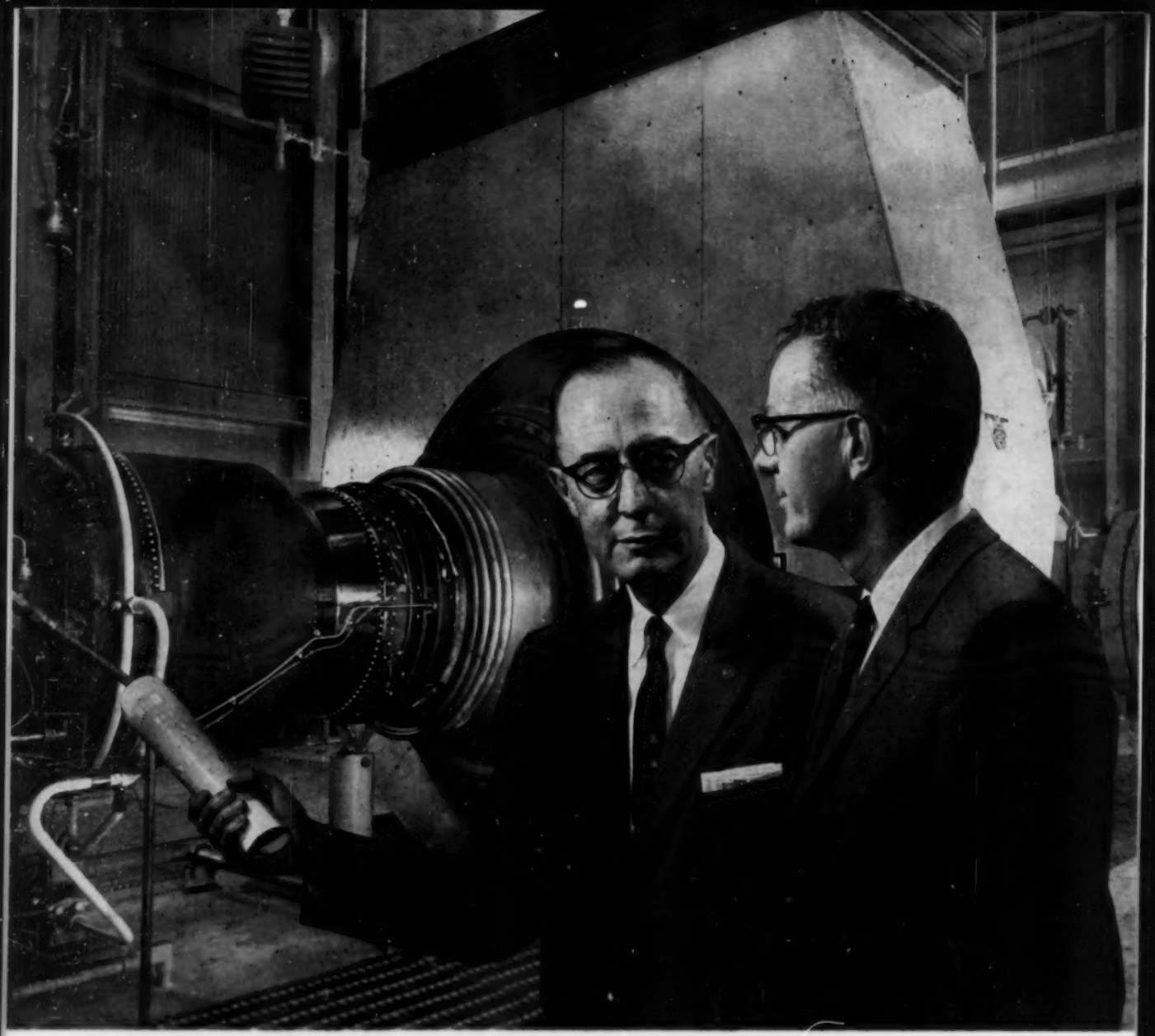

R. L. Boyer, *Vice President and Director of Engineering, and* W. B. Boyum, *Manager of Gas Turbine Sales, The Cooper-Bessemer Corporation report . . .*

# World's first jet powered gas turbine is now on the job

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## COLUMBIA GAS SYSTEM

**plans 470 miles of Collins microwave . . .**

# COLLINS MICROWAVE AND CARRIER

United Fuel Gas Company, a subsidiary of The Columbia Gas System, Inc., has ordered the first section of a Collins microwave system. When completed it will span four states and provide this major natural gas utility with complete facilities for voice communication, teletypewriter service, telemetering, supervisory control and data communication. Expandable to 240 channels, the Collins microwave system will be a part of a broad automation program being planned by Columbia.

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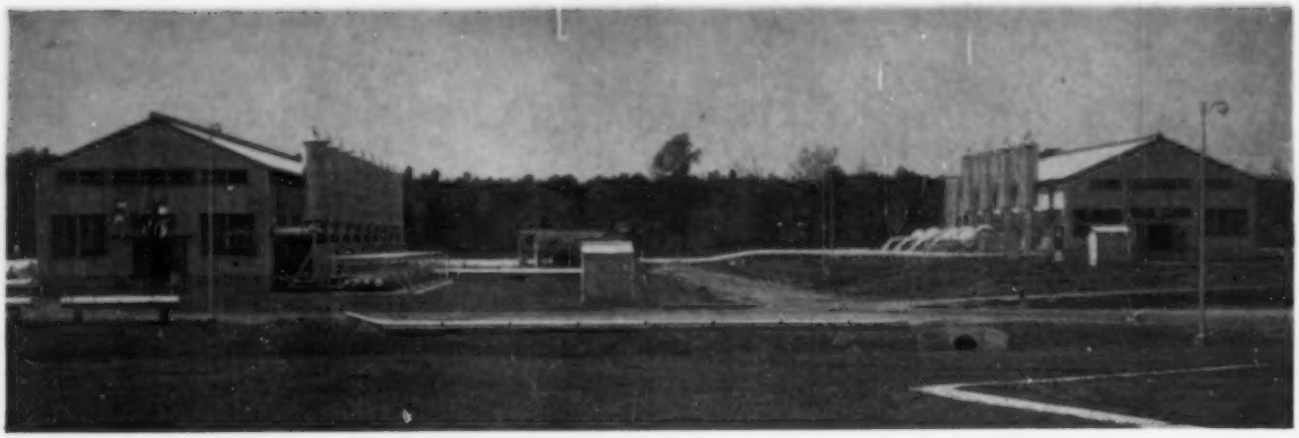

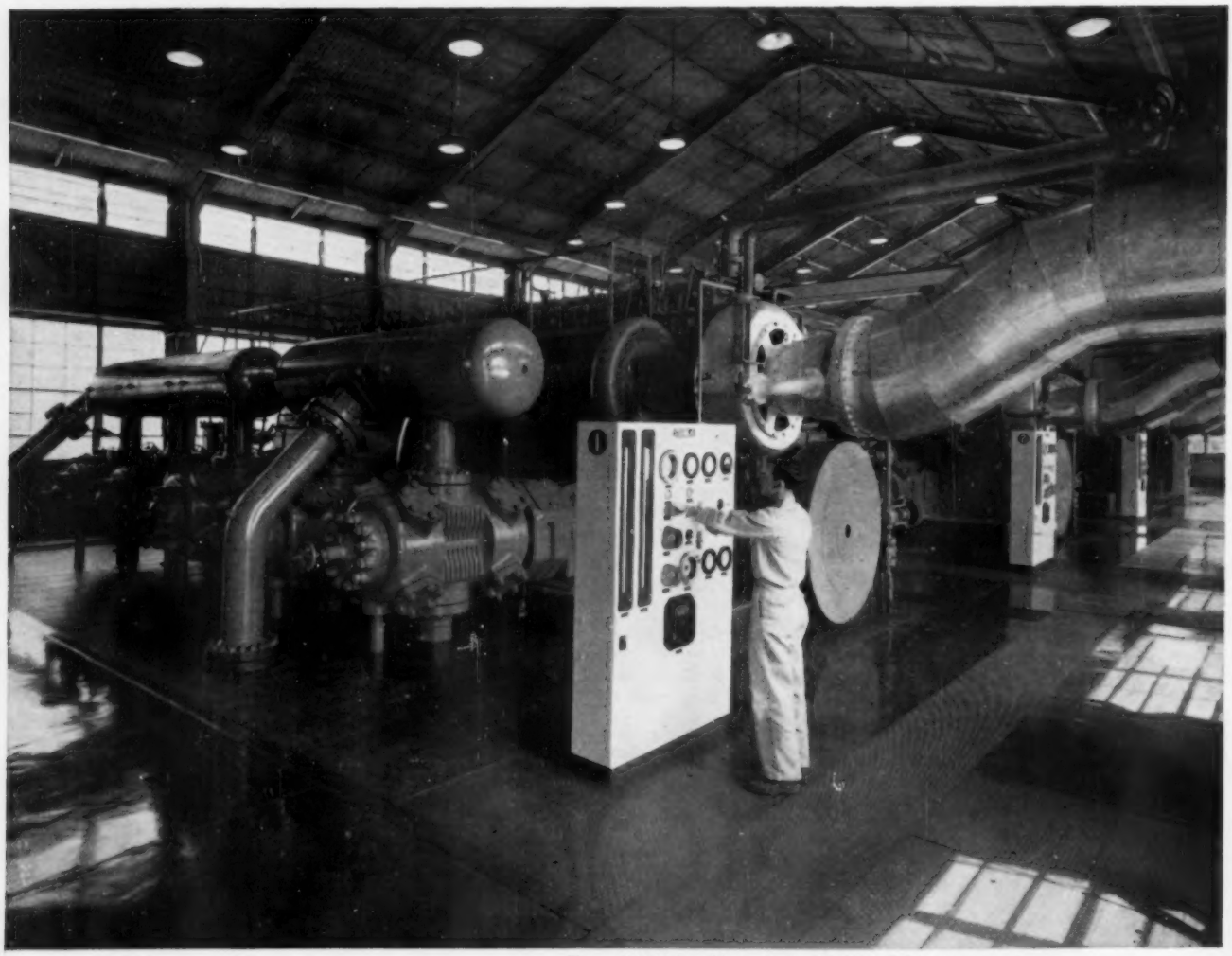

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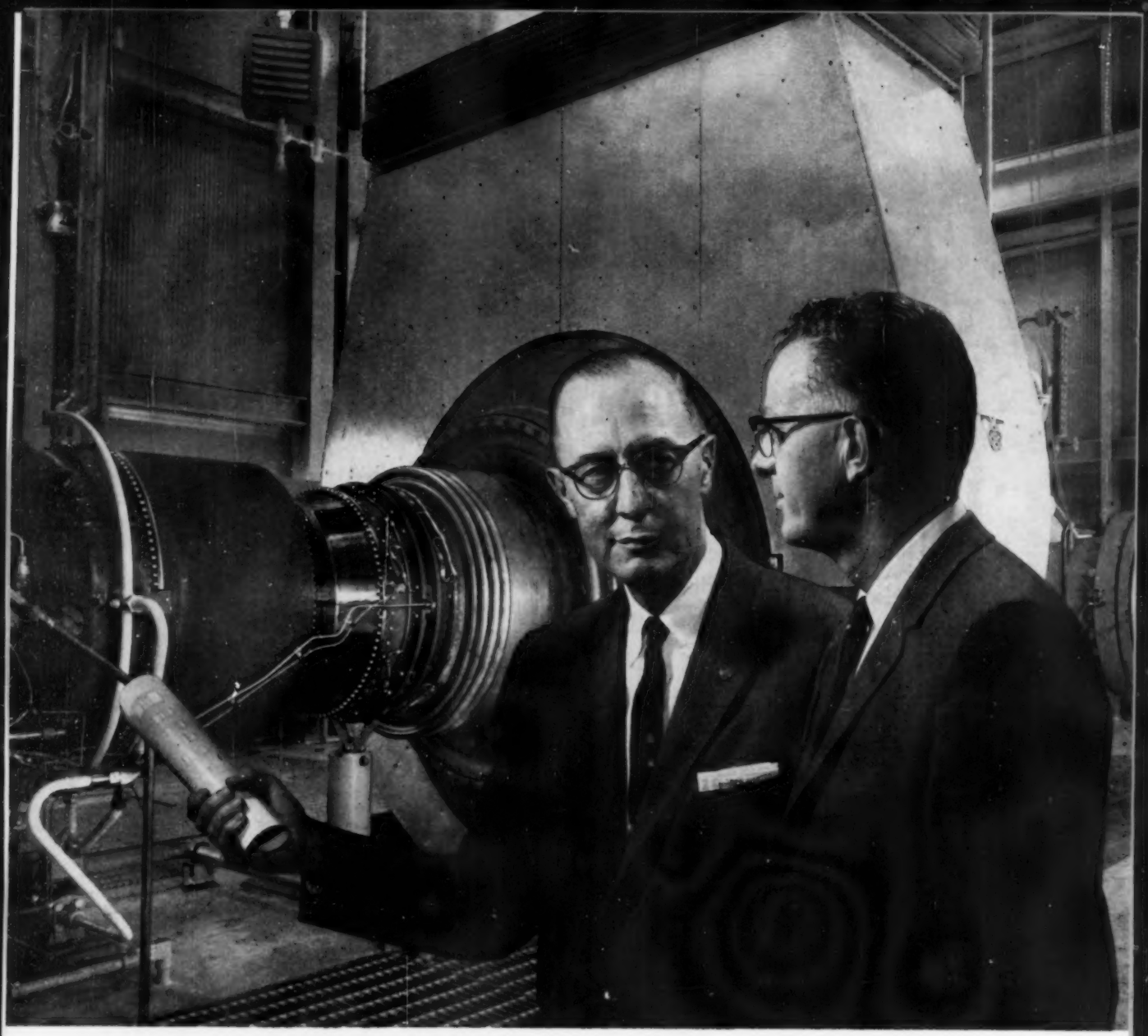

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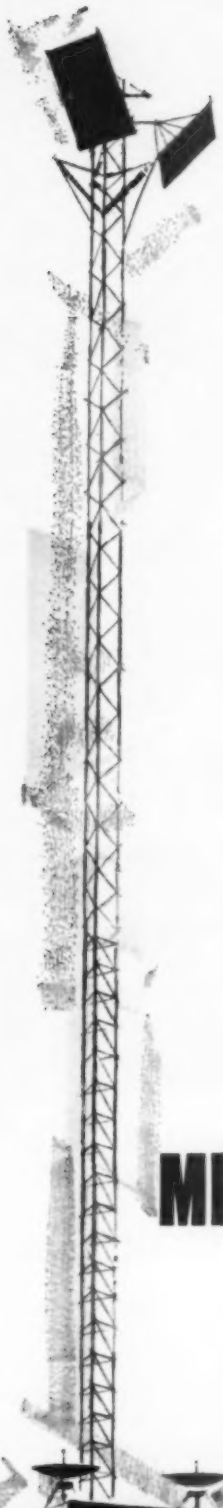

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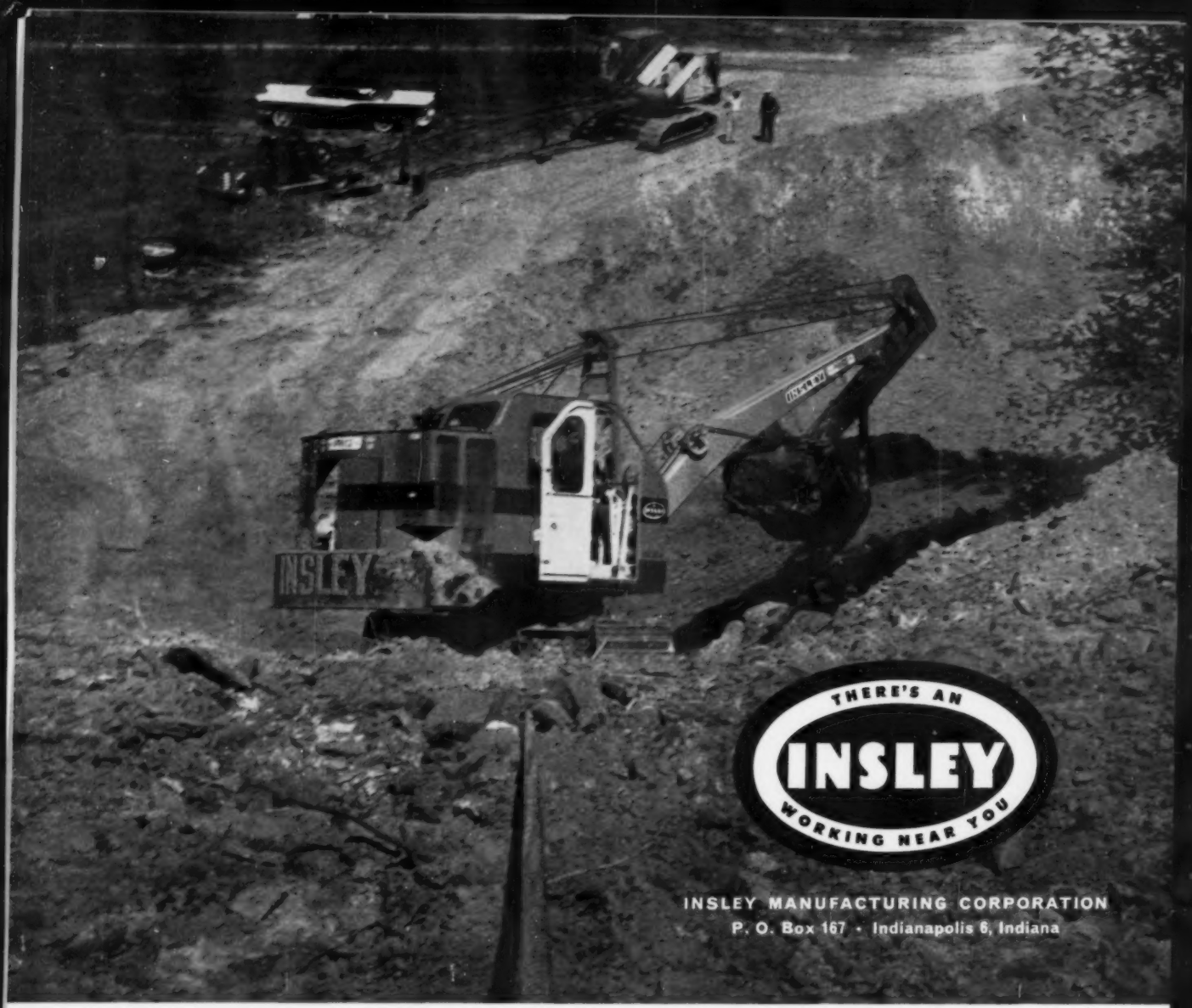


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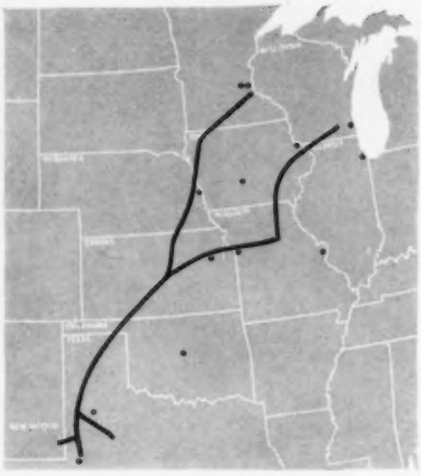
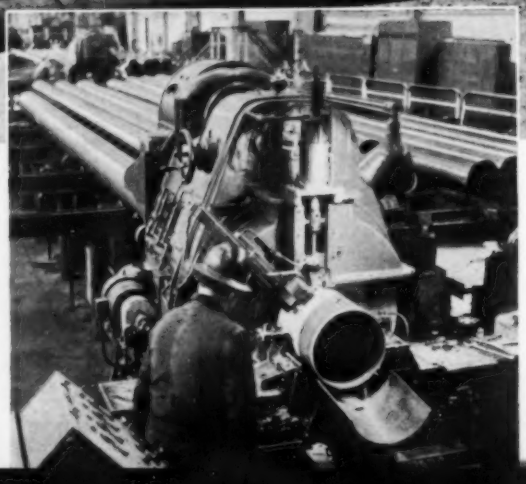
# Bethlehem Line Pipe Performs for Mid-America Pipeline



For this 2,200-mile LPG pipeline, Bethlehem furnished some of the longest line pipe on record. Lengths of the 8-in., X52-Grade pipe reached to 62 feet! That's mighty long pipe. And every inch of it is top-quality . . . the kind that keeps pipeliners moving at top speed.



▲ *In a Kansas field, Bethlehem pipe waits for the stringers. Extra-long lengths, squared ends, and accurate bevels mean fewer and faster welds, smooth installation.*

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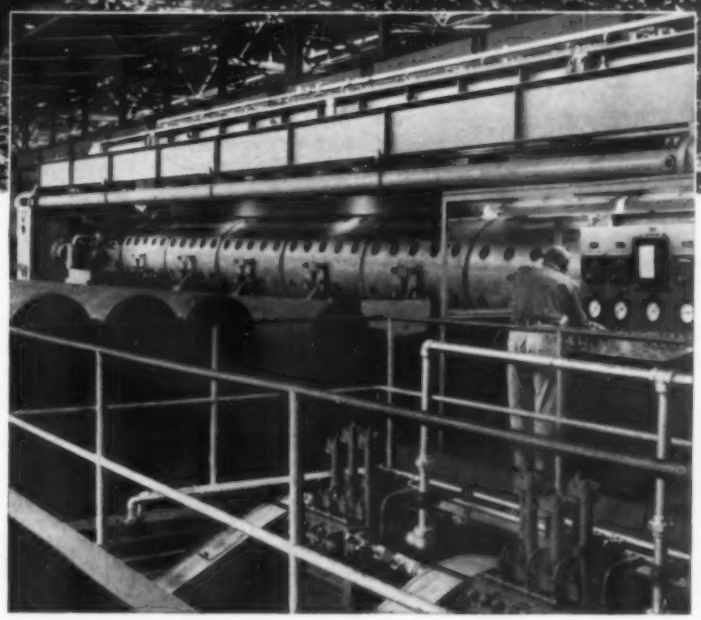
**Bethlehem Electric Resistance-Weld line pipe** *is produced on modern facilities at our Sparrows Point, Md., plant in sizes from 5-9/16- to 16-in., OD, in lengths to 62 ft.* ▶

▲ *Williams Brothers Company, Tulsa, engineered and constructed the line for Mid-America Pipeline Company, also of Tulsa.*



**Electric Fusion-Weld line pipe** *facilities, newly-installed at Bethlehem's Steelton, Pa., plant, turn out pipe from 18 through 42-in., OD, with walls to 3/4-in. in all diameters.* ▶

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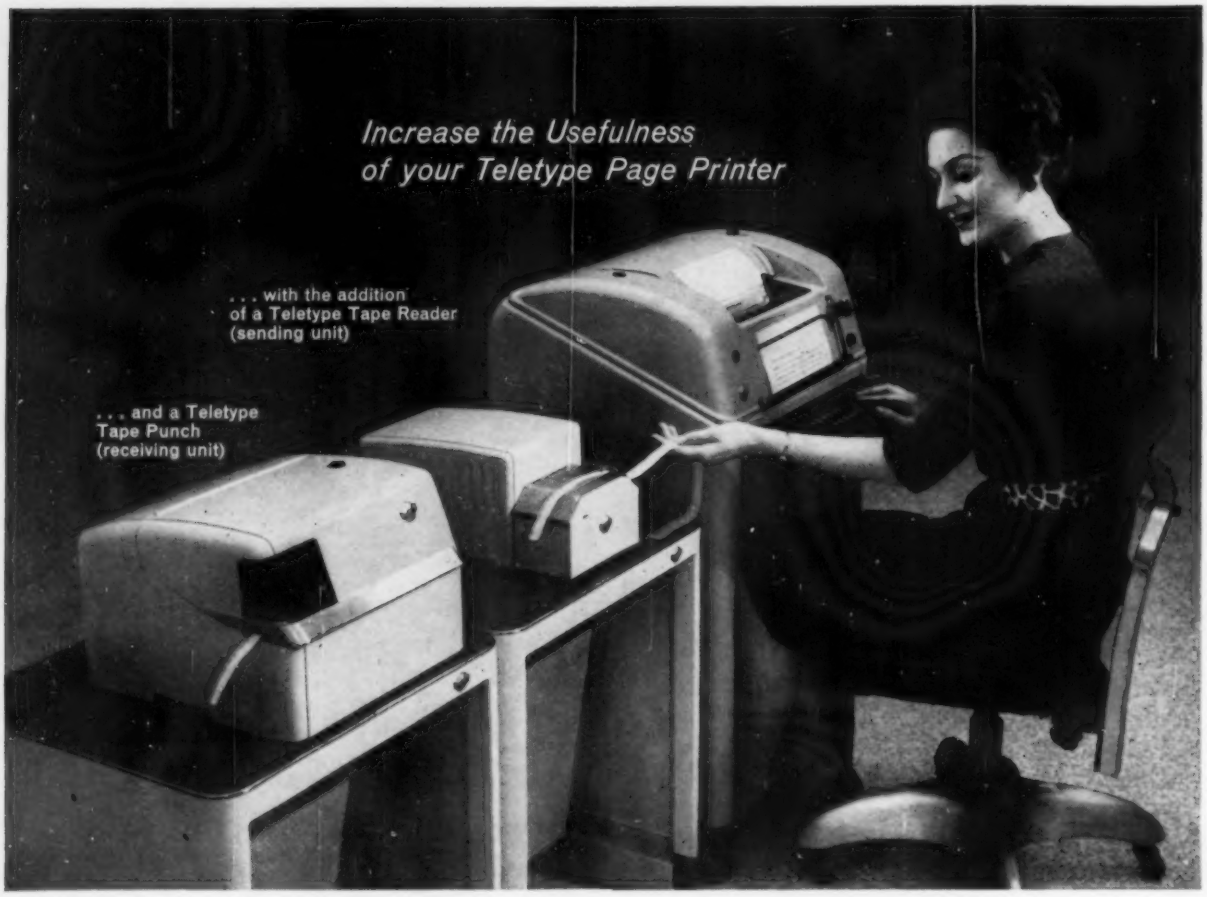
BETHLEHEM STEEL

# BETHLEHEM STEEL

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Adding Teletype tape units to your present Teletype page printer can pay you handsome dividends. As your printer is used for sending and receiving messages and data, the information can at the same time be captured in perforated tape form—as a by-product, without effort on the part of your operator. This tape, then, has many cost-saving uses:

**Save time, increase capacity**—the tape can be used to retransmit all or part of the information to other locations . . . it is an easily storable record . . . it can be used over and over to save typing effort.

**Greater accuracy, efficiency**—using punched tape for repetitive data such as addresses, product descriptions and other fixed information not only eliminates retyping but also saves possible errors in preparing purchase orders, sales records, payrolls and the like.

**Business machine tie-in**—the tape is compatible with many modern business machines and can also serve as "input data" for certain types of computers.

In these and many other ways, the addition of Teletype tape units to your present Teletype page printer can pay you important dividends. Teletype Corporation manufactures this equipment for the Bell System and others who require the utmost reliability from their data communications. Teletype equipment can be used with Data-Phone and other communications services.

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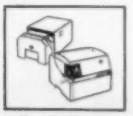
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# What can the pipeline industry expect under the KENNEDY administration?

E. E. HALMOS, JR.
*Washington Correspondent*

**Evaluation of factors indicates little change in policy the first year . . . but after that a number of things could happen.**

IT NOW APPEARS that the first session of the new 87th Congress will pass no legislation specifically aimed at the pipeline industry, with one possible exception. Seemingly, the attitude is that present laws controlling operations and construction are working well enough that changes will not be pushed this first time around.

The exception is the possible reappearance of the perennial "separation of ownership" bill (divorcement), but its chances of enactment are considered small.

Considerable other legislation before the congress will affect the pipeline industry in a secondary way, however. And there may be some hair-raising proposals from the administration in the matter of tax revisions, labor legislation, etc. . . . but there is little possibility that much of it will get through the congress.

This is the best estimate that can be made in Washington as the Capitol watched a complete changeover in political control of the executive branch of the government for the first time in eight years.

**The conclusion at this time, then, is this: Look for little real change in the policies and actions of the federal government, at least for the next year.** Changes may come about after that . . . when congress begins to worry about the next mid-term elections.

In attempting to assess what is likely to happen, the amazingly slim popular vote margin of the successful candidate must be considered, along with the facts of political life in Washington and campaign pledges.

The key factor is the popular vote . . . its significance is not lost on the practical politicians who make up the congress. Although Mr. Kennedy must act like a winner, of course, and will attempt to "hit the ground running" with a fistful of proposals, the fact is he hasn't the huge and affectionate popular following that President Eisenhower had throughout his eight years. Thus a Kennedy threat to go over congress' head would not frighten many people.

Of course, it is true that any president has certain powers (such as patronage) that can be used for leverage against a recalcitrant congressman — but it is also true that Mr. Kennedy probably will hesitate to use such powers, at least in the first year. Mr. Johnson's effectiveness in the senate, as vice president, has yet to be revealed: But remember that a vice president in reality has no power at all, despite any statements by his president.

## Congress Will Be in Driver's Seat

So it has come about that congress will be in the driver's seat in government for the first year, anyway — President Kennedy has little choice but to go along with the legislative branch if he wants any of his program enacted. And congress is basically conservative — has been for some years, and is strengthened in that regard by the slight Republican gains in both houses. The committee chairmanships in both houses, with few exceptions, remain firmly in the hands of the southern contingent. Moreover, some of the southerners are considerably more conservative than the Republicans in matters affecting economics and business conditions.

As to the Republicans: In some ways they are in a better position as an opposition group than they were under President Eisenhower. Without a president of their own who must be supported, GOP congressmen have considerably more freedom to oppose legislation than they had in the previous administration. Already there is ample evidence that they are moving to consolidate their long-standing alliance with conservative Democrats.

## National Transportation Policy

An apt example of what is happening is contained in two reports — one by the new administration, the other by the senate's interstate commerce committee staff — on the subject of national transportation policy.

The administration report (contained in a survey for Mr. Kennedy by Dean James M. Landis) called for the establishment of an office of "Coordination of Transportation Policy" within the president's official family, to work out policies for a later date, and for strengthening of the regulatory agencies, such as the Federal Power Commission, through various means, including more prestige for the chairmen.

But the senate committee report (very carefully labeled a staff report, not an official committee report) went much

further: It called for the establishment of a "Department of Transportation," to take over policy and planning functions of numerous independent regulatory agencies, and some now exercised by the established federal departments; and establishment of a sort of super commission to handle regulatory and judicial functions now handled by these same organizations. It also called for placing of tolls on waterways, establishment of a "trust fund" modeled on the existing highway trust fund to pay for waterways improvements, etc.

Of course, any action that would change the status of the Federal Power Commission, the Interstate Commerce Commission, The Army Corps of Engineers, and other such agencies would have an immediate effect on pipeline operations.

It seems clear, however, that the Kennedy administration would prefer not to have a fight on this matter right now — and a fight is inevitable if an attempt is made to consolidate many of the long-standing operations, however laudable the end objective may be. The new president would rather concentrate on his "must" legislative program (see below), put this one off for a while through the appointment of a staff man to look into the situation, possibly come up with a report and legislation backed wholly by the administration next session.

Result, it now appears, will be a lot of sound and fury — but no legislation this time.

### Political Facts of Life

There are also other political facts of life to be considered:

1. There will be two budget messages this year — one, as required by law, submitted by President Eisenhower, the other by the new president as soon as possible after his inauguration. The chances are that the Eisenhower budget will prevail with some changes — there simply isn't time for the new administration to do much more than pare or add funds, in view of the enormous, months-long work that goes into preparation of a budget.

2. Of course there has been a wholesale replacement of cabinet officers, and in policy-making areas below the cabinet level. But new men in government departments do not insure changes — the enormous inertia of a huge department has to be seen to be appreciated. Health, Education and Welfare, for example, is the newest cabinet department — eight years old — and already has over 65,000 employees. Tendency of new secretaries is to lean on career employees, and that usually insures a continuation of existing policies.

3. Much of the government's operations are almost beyond the control of the president anyway — the independent agencies, for instance, many of which are run by men whose terms of office are not dependent upon the president's wishes. And many of the departments and agencies are solidly embarked on programs provided by law which will continue for years, unless the basic law is changed, or appropriations cut off.

In view of this, then, action during the next few months shapes up about this way:

President Kennedy will get, rather quickly, four or five pieces of legislation that both parties supported last year but failed to pass because of minor differences: (1) Some sort of federal-aid to education; (2) urban renewal and depressed-area relief; (3) more money for sewage disposal works; (4) some kind of aid for the elderly; (5) some more "new starts" for public works projects; (6) probably a little more money for military construction.

Quick action here will look good on the record.

But there is no certainty at all that a number of other matters, dear to the new president's heart, according to campaign statements and past performance, will pass congress. Of those that will affect pipeliners more or less directly, most must be put in the doubtful category, like this:

**A. Changes in the minimum-wage "floor" (raising it to $1.25 an hour and broadening it to include many more workers).** In the bills that were presented to both houses last year, it will be remembered, traditional exemptions for pipeline workers were removed, then hastily restored, even though the bills finally did not pass. This proposal will certainly come up again, but Southerners, in general, oppose any great broadening of coverage.

**B. "Common situs" picketing relief, demanded by the construction unions.** This also failed last year, although unions argued they should be permitted to strike an entire job even though their dispute was with only one of many subcontractors. There will certainly be a new drive on this, but, again, it doesn't seem likely that congress will buy it.

**C. Formation of a new cabinet-level Department of Urban Affairs is also doubtful.** It is in the same category as the "Transportation Department" already discussed. Such a department also would consolidate or take over a lot of functions now carried on by many agencies, pose a whole new set of procedures and people for pipeliners to deal with. The drive for Urban Affairs already is well started by big-city officials (and in the form of some six bills introduced within a day or two after the opening of the congressional session). But congressmen from rural or small-town areas (and they are in the majority) apparently can't see giving the cities any more power.

**D. Tax revisions.** Here is where the hair-raising will be done, as the new administration tries to find more revenue to support its expected expansion of government spending. First steps will be in the favorite area of "loopholes" — depreciation allowances on equipment, expense accounts, foreign-developed funds, etc. Congress will go along with some of this, but apparently won't stand for too much interference with business practices.

### Other Areas of Governmental Study

On the depletion allowance, during the campaign the democrats soft-pedaled talk. But there is no indication of any real attempt to reduce the existing 27½% — even though Senators Douglas and Proxmire will try as usual.

One other area might come up for study — though, again, there is little indication of any major changes impending. That is the current regulation of residual oil imports, which is being carried out under a presidential order, not a specific directive from congress. Significant here is the fact that the New England states last year did a lot of yelling (through Senators Saltonstall and Kennedy among others) about having to pay too much for fuel oil because of import restrictions. As president, Kennedy might want to consider easing those restrictions.

The whole federal-aid highway program also will come up for another look, and a possible rewriting of the 1956 law. The Bureau of Public Roads has brought in a whole series of key reports on costs, user charges, taxes and the like — and congress is certain to use them to reconsider the bill. Among the controversial points (in addition to the possibility of increased gasoline taxes) is one of particular interest to pipeliners: Payments for relocating lines where they cross under a highway right-of-way. ★ ★ ★

**EQUIPMENT MAINTENANCE**
*. . . one of a series*

# PROPER SERVICE MINIMIZES REPAIRS

**A. L. LUNDBERG,** *Equipment Superintendent*
*O. R. Burden Construction Corporation*

THE ACCOMPANYING PHOTOGRAPH shows a new idea in a service truck for heavy equipment on pipeline construction. Proper servicing on the job is an important part of maintenance . . . minimizing repairs.

The truck was designed by the writer and built under his supervision in the shops of O. R. Burden Construction Corporation in Tulsa, Oklahoma.

As can be seen, 400-lb grease and oil drums have been mounted in each corner, lowered into specially constructed wells. This accomplishes two things:

(1) The lower center of gravity lessens tipping and rolling while traveling over rough terrain. Also, the lower position of the equipment facilitates traveling through brushy areas.

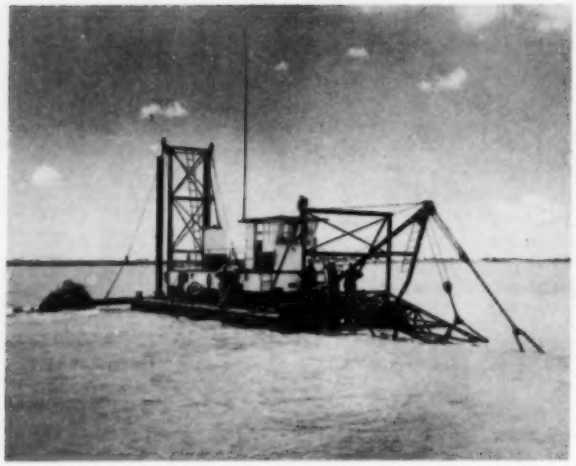
(2) The equipment is much easier to work and simplifies the loading of additional barrels.

The truck is equipped with five dispensing reels, one each for track roll, chassis lube, transmission oil, motor oil, and air. The air compressor is started electrically, and an electric plant is mounted on the truck bed for this purpose, and to provide light for night work.

A storage or tool box is mounted on either side under the truck bed, both of which are waterproof. The larger one on the right side carries filters and supplies. The tool box on the left side is for tools, fittings, etc.

The truck has been provided with a "No Spin" axle, which makes it almost as versatile as if it had front wheel drive.

Material from the right side of the truck is piped under the bed to the reels on the left side. The reason for putting reels on the left side is because they are handy for the driver as he dismounts from the truck, and, also, it is an improvement over the rear-mounted reels as they do not collect as much dust and dirt. ★ ★ ★



The barge with trenching unit submerged astern and in operation. Dispersal of spoil can be seen.

Closeup of trenching machine. Large-diameter pipe takes spoil from digging equipment into two 12-in. across-the-deck dispersal pipes that extend outward 16 ft from the stern.

# SPOIL-BANK PROBLEM SOLVED

## *. . . in shallow-water trenching*

RUEL McDANIEL

ELIMINATION of the spoil-bank problem in bay and other shallow-water trenching when laying submarine pipelines is made possible with a new trenching machine recently built and put into service by King Fisher Marine Service Inc., Port Lavaca, Texas.

The new dredge-trencher combination digs a trench 4 ft deep and 6 ft wide at the rate of 8 to 10 ft per min in average bay bottom, according to King Fisher, head of the company and designer of the unit.

The trencher basically consists of a metal "box" containing two 5-ft cutters and a suction beneath them. As they revolve and cut out the dirt, the suction carries it into dispersal pipes and the result is a completely clean trench. The trencher is mounted on the stern of a barge 18 ft wide and 48 ft long.

The spoil goes into two 12-in. pipes, each extending outward from the stern of the barge about 16 ft. It is deposited from the pipes with a force sufficient to scatter it over an area of several square yards. Dispersal is so wide that at no time has there been more than 3 in. of deposit along the trench, Fisher declares.

Although the dredge cuts a trench 6 ft wide and 4 ft deep, the normal depth required for laying a shallow-water pipeline, if greater depth is required this is done by passing the dredge over the trench again and again, until needed depth is accomplished. The maximum depth that may be economically made through repetition of the operation is 12 ft. The unit is capable of operating efficiently in water as deep as 20 ft, Fisher says.

Movement of the dredge-trencher is by cable, anchored ahead of the rig. The single-drum winch on the bow contains 1500 ft of ⅝-in. cable. The outer end of the cable is affixed to the anchor, which is moved forward the desired distance by a tug and dropped. With the anchor in place, the winch slowly winds in the cable, pulling the barge and trencher forward at the predetermined speed required.

The hydraulic pump is powered by a 600-hp diesel engine, and auxiliary power is from a 150-hp diesel. Motor-driven generators provide electric power.

Under normal conditions, there is no problem in keeping the dredge-trencher in a straight line, merely by keeping the cable taut, but in event of strong winds or heavy cross-currents, a straight line may be maintained by the use of side anchors.

"The spoilage dispersal feature of the unit is vitally important to us," Fisher declares, "because the U. S. Engineers and the State Game and Fish Commission no longer permit spoilage banks to be thrown up in navigable bays due to the navigation hazards. Under former methods of trenching, disposal of the spoilage to prevent formation of spoilage banks was a major problem. This machine eliminates it, because the suction and pipes scatter the spoilage so well that it cannot build up a bank. So far we have encountered no more than 3 in. of built-up spoilage."

The barge and trenching machine were designed by Fisher and built in his own shipyard at Port Lavaca.

An interesting added feature of the rig is that the entire unit may be dismantled and hauled by truck overland. Two days are required to dismantle and load the rig, three days to unload and assemble. ★ ★ ★

**JOHN G. BOMBA,** *Civil Engineer, Collins Construction Company*

# SUBMARINE PIPELINE CONSTRUCTION METHODS

**PART 2**

During the pipe pulling operation, a set of design catenary ranges was employed to enable engineers in the survey craft to locate the nose of the pipe at any time with a fathometer. Surveyors located on shore turned angles on these survey craft and relayed positions by radio to the instant plotting board located in the control tower. The position of the nose of the pipe was noted on the pre-programed horizontal control sheets.

Engineers in charge of the pulling operations followed the progress of the pull, and when the nose of the pipe deviated slightly from its prescribed path, corrective measures were taken immediately. With the true location of the pipe known, adjustments of the holdback and the catenary barge cable tensions corrected the location of the pipe to the design catenary.

With the pre-programed horizontal control sheets currently available and with the precision of the instrument procedures used, the actual location of the pipe was known to within a radius of 1½ ft.

As in all of Collins' installations, the pipe was welded into strings along the launchway, X-rayed, tested, wrapped, and concreted.

The pulling winch was set on top of the west bank levee and the pull cable strung across the river on the installation catenary by a barge using the range targets for alignment. A holdback winch was positioned behind the pipe strings on the east bank of the river.

The first string of pipe was set on the launching units, pontoons attached, and the pulling and holdback cables secured.

The catenary barge and pipe guide barges were positioned and the installation was begun. Fig. 7 through 10 illustrate graphically the movements of the pipe and the barges during pulling operations.

## Hudson River Crossing

In May of 1959, Transcontinental Gas Pipeline Corporation was in the middle of a construction program to increase the supply of natural gas to New York City by 35%. The last and most important stage of construction was yet to come. The Hudson River had to be crossed.

Samuel Gallucci and Sons and Collins Construction Company were the contractors for the submarine installation.

Preliminary surveys by Transco's engineers had shown that a site near Manhattan's 72nd Street was the most suitable location for the river crossing. The maximum water depth found along the 4200 ft crossing was 80 ft, and corings taken along the uniformly sloping bottom had encountered no rock above – 105 ft.

The Hudson River in this area is a busy waterway. Ocean-going vessels and numerous river boats pass the crossings site every day. Repairing or replacing a pipeline damaged by ship's anchors is not cheap; so burial of the pipe to at least 25 ft below natural bottom was specified. The contractors called in Great Lakes Dredge and Dock Company to excavate a trench 25 ft deep and 20 ft wide at the bottom.

Because an uninterrupted supply of gas to the Manhattan shore had to be maintained, Transco decided to install two 24-in. diam pipelines across the river.

To provide enough weight to keep the lines in the ditch after installation, Transco had H. C. Price Company apply a ⅝ in. thick coating of Somastic to each joint, followed by a 2-in. thick reinforced concrete jacket. Gallucci trucked the coated joints to the work area (Fig. 2).

Ideal as the river crossing site was, finding a suitable pipe make-up area was a problem. The contractors finally decided to use a 160-ft by 300-ft area in Manhattan's Riverside Park. The New York City Park Department required that each shrub and tree be carefully dug up and the roots balled in soil and burlap, and that each be replaced after construction.

The bank approaches were dug and pipe make-up operation began.

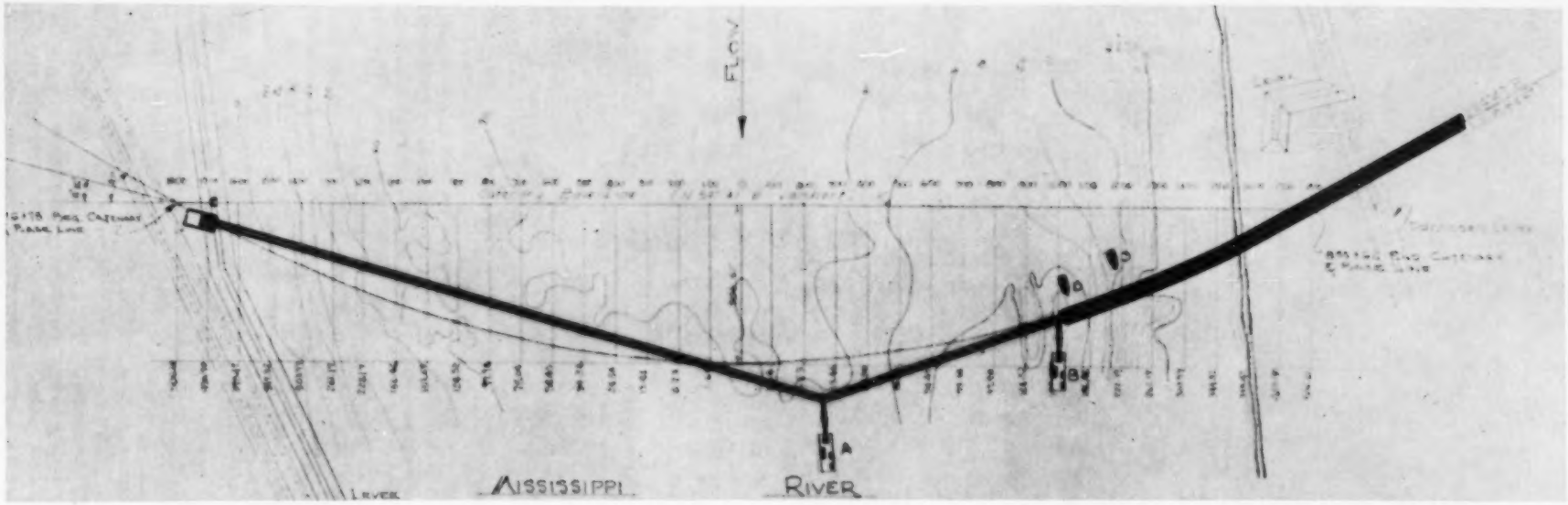



FIG. 7. Catenary (A) and pipe guide (B) barge positions at 1/5 point of pull. Catenary barge is constantly changing position during pull to hold cable tangent to design catenary.

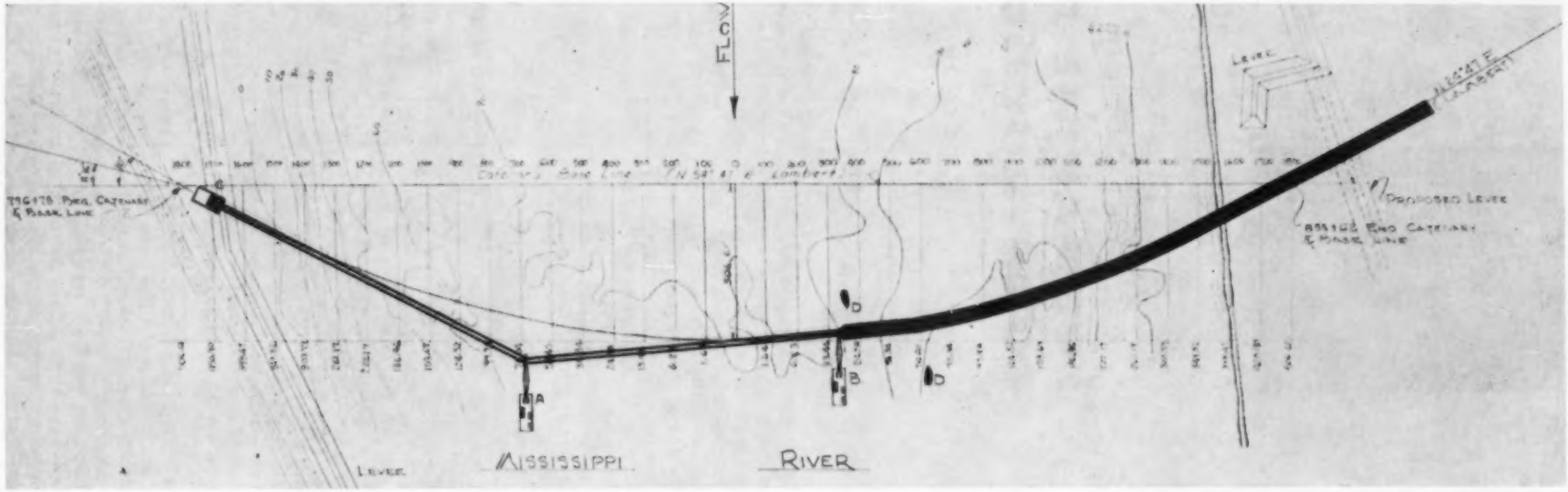



FIG. 8. Position at 2/5 point of pull. Survey craft (D) criss-cross pipe locating nose and trailing section at least once a minute.

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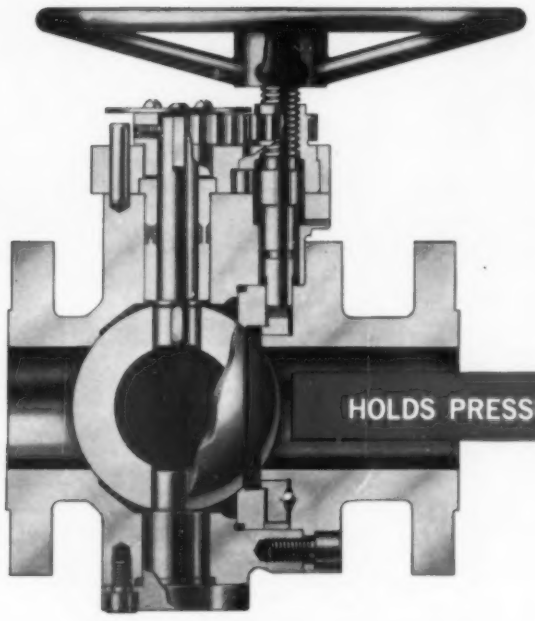


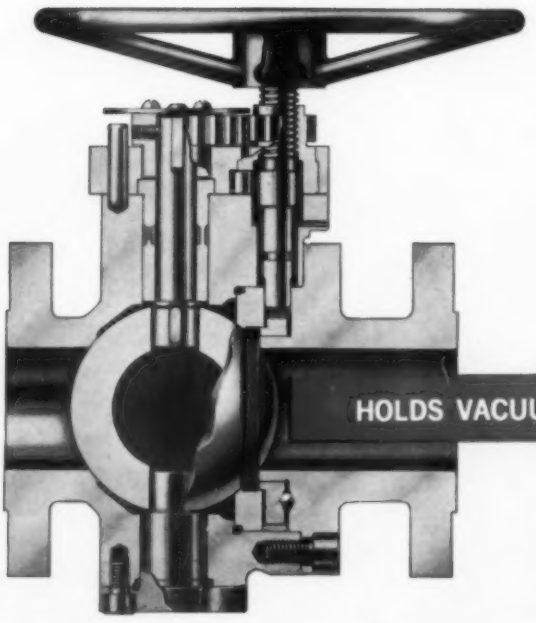


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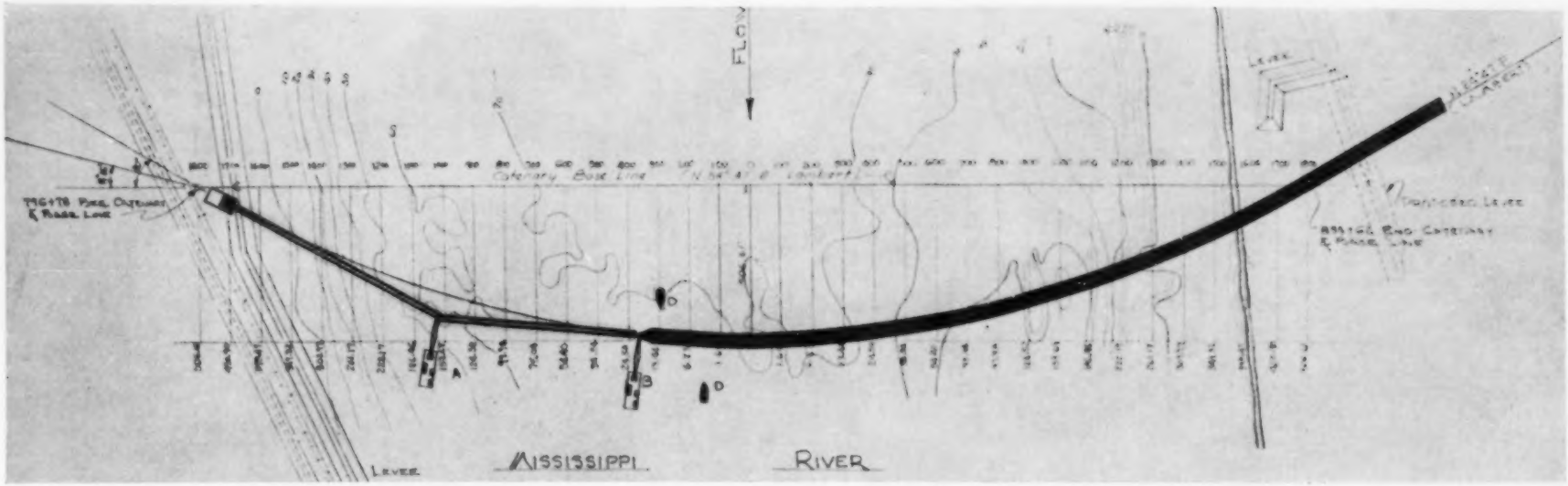


FIG. 9. Pull at 3/5 point. Adjustment of tension at pipe guide barge (B) and holdback winch correct pipe deviations from design catenary.

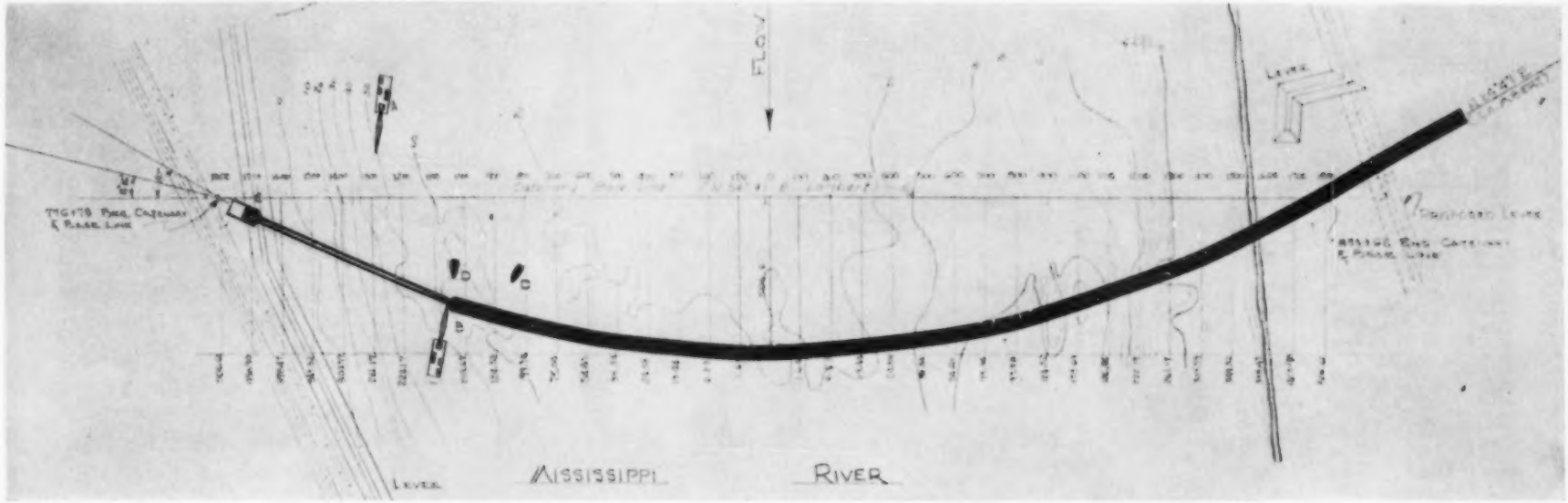


FIG. 10. Catenary barge (A) is removed from pull cable at 4/5 point. Pipe guide barge continues to maintain pipe alignment.

Welders assembled the 8500 ft of pipe into 52 strings, each 160 ft long. The field joints were then X-rayed, polyvinyl-chloride taped, and the outer concrete jacket was applied.

Collins' Seamaster Winch was set in place on the New Jersey shore. A holdback winch was set at the rear of the work near Manhattan's Riverside Drive.

Before any pipe was allowed to enter the water, special precautions were taken to insure a clean ditch. A sled, designed to push any obstructions that might be found ahead of it, was pulled along the ditch bottom from New Jersey to New York and back by the Seamaster and holdback winches. Satisfied that the ditch was clean, Collins' personnel was now ready to pull pipe.

FIG. 11. Ditch cleaning sled on the New Jersey shore of the Hudson River. Seamaster winch, shown, and Collins holdback winch on opposite shore pulled sled back and forth across river.

FIG. 12. Collins' pontoons being banded between the dual lines. Holdback winch (not visible) was situated directly behind launchway.

Patented rubber-tired launching units were set side by side parallel with the elevated pipe racks.

Gallucci's cranes then set the first two strings on the launching units. A special pulling yoke, designed to distribute the pulling load equally between the pipelines was welded to the forward end of the two strings. Pontoons, with a net lift of 12,000 lb were banded at intervals along the lines. These would reduce the weight of the pipe to 20 lb per ft in water. The holdback clamps were connected to the holdback winch by a cable and sheave arrangement. The buoyant block and pulling cable was connected to the yoke and the pull was started, 160 ft of the dual line going into the river at a time.

String tie-ins soon became routine. Setting two strings on the launching units, welding, X-raying, tape and concrete coating, pulling, and diver inspection of the lines averaged five hours. Total installation time was less than one week.

After the pipelines were pulled ashore on the New Jersey side, a final inspection was made and the pontoons were removed. The pipe ditch was then back-filled, and the pipelines were tied in with Consolidated-Edison's gas main on Manhattan Island and Transco's main line.

The Collins' "Continuous Marine Traffic" method was used for the dual line crossing. A unique feature of this method is the complete absence of floating buoys or barges, which might hinder normal river traffic. Patrol boats are used to warn ships not to drop anchors near the crossing site. Both pulling and holdback forces are measured with sensitive hydroscales and recording dynamometers. These measurements are used by Collins' engineers as an aid to prevent over-stressing the line in tension. Each pull is analyzed closely, and maximum allowable loads are given to operating personnel, who have instructions to stop the pull if limits are equalled or exceeded.

Originally designed and used to install Transco's first line into New York, the 134th Street Crossing in 1959, this method has been used successfully in more than 20 crossing, including the dual line crossing of the Straits of Mackinac in 1953 and several Mississippi River and Atchafalaya River crossings.

## References


[1]Tindall, Dan C., "How River Crossings Are Surveyed and Designed," *Pipeline Engineer*, June 1957.

[2]Brown, R. J., "High Accuracy Control Systems for Submarine Pipelines," *Oil and Gas Journal*, June 6, 1960.


★ ★ ★

# Pipeline Projects

## Firms Study $30,000,000 Products Line From Jersey, Across Narrows, To Long Island

A New York investment firm plans to build a $30,000,000, 75-mile products pipeline across densely populated Long Island, New York, in 1961.

Gulf Interstate Company has prepared an engineering and economic report on the project for the Carl M. Loeb, Rhoades & Company, it is reported, and may join Loeb as a partner in the project. A new firm, Long Island Pipeline Company, would be formed to operate the system.

The route of the proposed line would be from the Linden, New Jersey, refining area eastward across Staten Island, under The Narrows waterway to Brooklyn, and on to LaGuardia and Idlewild Airports and other consuming areas on Long Island.

With a peak-day design capacity of 300,000 bbl and an average daily capacity of about 225,000 bbl, the 20-in. line would carry automobile and aviation gasoline, jet fuel, and home heating oils to existing terminals and others that are on the planning board. Arrangements have been made with the Long Island Railroad for a substantial portion of the pipeline route to be along their right-of-way, a Loeb spokesman said. He indicated that Loeb hopes to connect the new line with the Harbor and Buckeye Pipeline terminals on the Jersey end of the system.

The Loeb firm also has an option to purchase a 24-in. line that already spans The Narrows.

## $4,500,000 Pipeline In East Ohio's '61 Plans

A new pipeline costing $4,500,000 is included in the 1961 expansion plans of East Ohio Gas Company.

The line will run from Streetsboro in Portage County and tie in with facilities in Kirtland in Lake County, then divide with a 20-in. line to Mentor Township and a 24-in. to Euclid.

Completion is scheduled for October.

East Ohio's expansion plans for the year call for the spending of $26,500,000, second highest in the firm's history.

Other projects scheduled include: enlargement of underground storage facilities at a cost of $2,240,000; drilling of 32 new storage wells between Akron and Canton, at a cost of $1,800,000; start of a new storage area in Wayne County near the Chippewa station, at a cost of $135,000; plus the drilling of production wells and construction of a service center in Wickliffe.

## New York State Natural Outlines Year's Projects

New York State Natural Gas Corporation has announced plans to invest $7,130,000 in pipeline facilities and production this year.

Major among the firm's pipelaying plans will be 30½ miles of small-diameter pipeline, as well as the construction of 35 measuring stations, in connection with a well-drilling program that calls for 30 gas wells in Pennsylvania and New York.

The company also will lay 11 miles of 30-in. pipeline from its Borger compressor station at Ithaca, New York, into Cortland County, to parallel an existing 20-in. line and provide increased capacity to meet expected peak day requirements in 1962.

Other projects planned: installation of compressor engines in three producing areas; supercharging of five compressor engines at Sabinsville, Pennsylvania, station; and installation of another engine at Utica station.

## NGPL Plans Loops Totaling 257 Miles

The Peoples Gas Light and Coke Company announces that its long-distance pipeline subsidiary, Natural Gas Pipeline Company of America, plans 1961 expansion projects totalling $52,310,000.

The most recent project, outlined in a certificate filing with the Federal Power Commission, would increase the pipeline company's daily delivery capacity by 60 million cubic feet through construction of 257 miles of 30-inch loop line and increased compressor capacity at a cost of $28,560,000.

Also pending is an earlier application of Natural Gas Pipeline to add 100 million feet in daily capacity through expenditure of $23,750,000 for supercharging compressors and construction of 89 miles of loop line.

In addition to these pipeline projects, Natural Gas Storage Company of Illinois, another Peoples Gas subsidiary, has been authorized to increase its storage withdrawal capacity in 1961 by 75 million feet daily.

## Compression, No Loops In Trans-Canada's '61 Plans

There will be no line looping programs for Trans-Canada Pipe Lines, Ltd., in 1961. Instead, according to James W. Kerr, president, emphasis in expansion for at least the next two years will be on compression to achieve maximum economy for flexibility in operation.

Present plans for additional gas turbines stem from the firm's experience with initial operation of new gas turbine engines which were installed with new compressor units in the 1960 construction program. Details of amount and location of new units and stations have not been decided yet.

Kerr also reported that deliveries on December 12 exceeded 600,000,000 cu ft per day for the first time to set a new high record of 70 percent more than the peak load in the 1959-60 winter heating season. Deliveries to the Midwestern Gas Transmission Company system at Emerson, Manitoba, accounted for more than half the increase.

Export demand is expected to grow so quickly that an additional export permit will be sought within two or three years, Kerr explained.

# SEC REPORT

## *Notes From News Digest*

**Plans $83,000,000 Construction.** Texas Eastern Transmission Corporation has filed registration statement for $30,000,000 first mortgage pipeline bonds and 150,000 shares of preferred stock, a portion of the receipts to be used to retire revolving credit notes and the balance in connection with a 1961 construction program involving approximately $83,000,000.

**1961 Expansion.** Texas Gas Transmission Corporation seeks registration of 300,000 shares of common stock. Net proceeds of the sale will be used to defray, in part, the estimated $27,000,000 expansion and construction program planned for 1961. Of this amount, 17,000,000 represents estimated cost of new facilities to meet projected requirements of certain customers for the 1961-62 heating season; and the balance represents expenditures in expanding underground storage facilities ($3,900,000), normal additions to the company's pipeline system ($1,600,000), and estimated cost of a new general office building in Owensboro, Kentucky.

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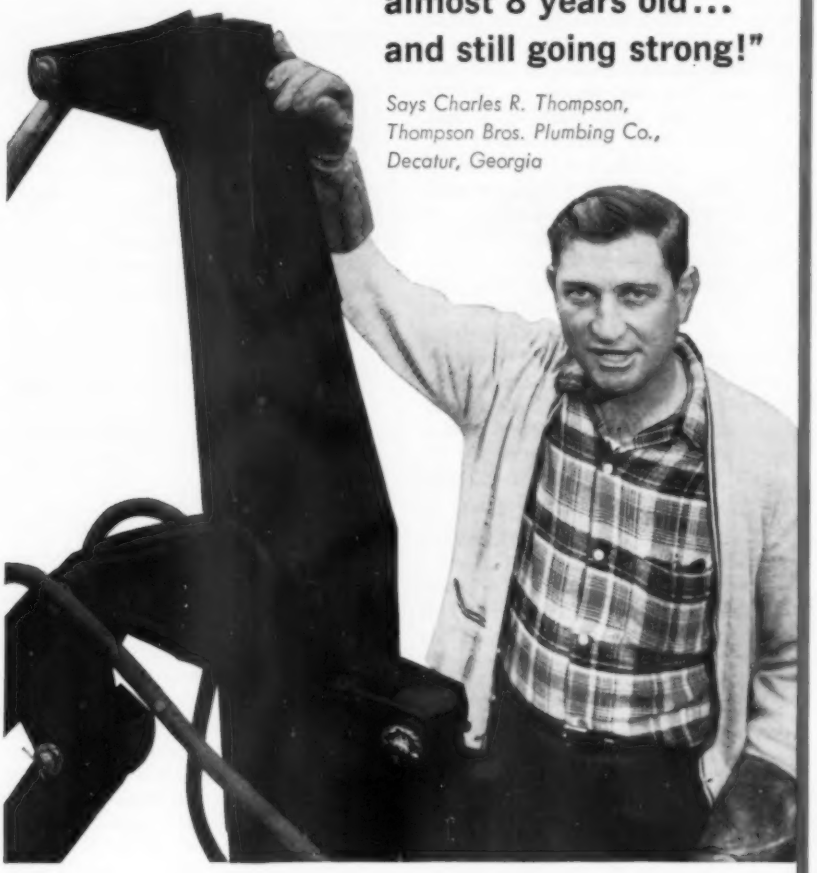

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# FPC FILINGS

## *Recent Applications For Gas Line Construction*

**Alabama-Tennessee Natural Gas Co., Florence, Alabama, CP 61-181, filed January 3, 1961.**

Description: 3.6 miles of 6⅝ in. OD lateral from 10¾ in. main line near Cherokee, Alabama, to an ammonia and ammonium derivative plant to be built by Armour & Company.

Cost: Total, $131,600; construction, $115,000.

**American Louisiana Pipe Line Co., Detroit, Michigan, CP 158, filed December 6, 1960.**

Description: Budget-type for lateral and gathering facilities, exact locations and facilities not yet ascertained. Applicant's pipeline extends from a point near Holly Branch, Louisiana, through Evangeline, Rapides, La Salle, and Carroll parishes, to a point near extreme northeast border of the state.

Cost: Not to exceed $3,000,000.

**California Gas Transmission Co., Los Angeles, California, CP 61-174, filed December 23, 1960, related to CP 61-172.**

Description: Presidential permit to import gas from Mexico and construct its share of the total pipeline system.

**Cities Service Gas Co., Oklahoma City, Oklahoma, CP 61-178, filed December 28.**

Description: Budget-type for miscellaneous meter and regulator equipment, construction and gathering lines in Texas, Oklahoma, Kansas.

Cost: Total, $3,000,000; single projects, not to exceed $500,000.

**CP 61-179, filed December 28, 1960.**

Description: Abbreviated. For 3 taps on lines, and meter setting and regulator stations.

Cost: Seneca, Missouri, $3,650 (tap on 16-in. line); Nixa and Ozark, Missouri, $3,400 (tap on 8-in. line); and Peculiar, Missouri, $1,470 (tap on 12-in. line).

**CP 61-183, filed January 5, 1961.**

Construction: Approximately 15 miles of 12-in. supply line from a point in northeast Grady County, Oklahoma, southwest to a point in Comanche County, Oklahoma; 4-mile, 4 and 6-in. gathering system to connect six wells; and appurtenant meter and regulator facilities at terminus of 12-in. pipe in Comanche County. Facilities to connect remainder of field between Comanche and Stephens County, Oklahoma, can be constructed within 12 months thereafter.

Cost: Material, $329,500; rights-of-way, $12,500; damages, $12,500; labor, $8500; contract work, $104,500; transportation and equipment, $7500; supervision and engineering, $30,000; records and warehouse, $10,000; insurance, $2000; interest, $6000; contingencies, $10,000. Subtotal, construction cost: $533,000. Estimated additional cost to connect and completely develop field, $142,000. Total: $675,000.

Materials: 15 miles main 12-in. supply line pipe, 12¾ in. by 0.1875 in., 25.157# X-52 electric weld; field gathering system pipe, 8⅝-in. by 0.1875 in., Grade B electric weld; 4½ in. by 0.142 in., 6.609# Grade B electric weld. All valves will be 600# ASA steel, with comparable fittings.

**CP 61-184, filed January 5, 1961.**

Description: Compressor facilities in Marion County, Kansas, and pipeline facilities leading from Rounds & Porter Lumber Company, Inc., gasoline plant to applicant's existing 26-in. main line facilities in Marion County, near Aulne, Kansas.

Construction: 10.5 miles of 8-in. pipe.

Cost: Materials, $105,700; contract work, $90,700; labor, $2500; rights-of-way, $3300; damages, $3300; transportation and equipment rental, $6000; engineering and supervision, $9000; records and warehouse, $3500; insurance, $3000; interest, $3000; contingencies, $20,000.

Construction: 6280-hp compressor facilities.

Cost: Materials, $1,202,000; labor, $136,000; contract work, $252,000; transportation and equipment rental, $45,000; engineering and supervision, $83,000; records and warehouse, $3000; insurance, $3000; interest, $20,000.

Materials: 10.5 miles of 8⅝ in. (new) by .1875 in. — 16.896# Grade B electric weld. All valves and flanges will be 600# ASA steel, with comparable fittings.

**Colorado-Wyoming Gas Co., Denver, Colorado, CP 61-165, filed December 13, 1960.**

Description: A number of main-line taps. Application comments that applicant receives numerous requests from utility resale customers for main-line taps to effect sales to resale customers in small rural areas. Applicant has three classes of main-line taps: "Farm Taps," which cost $100 and for which company supplies tap and valve, with customer supplying meter; "Small Group Taps," costing $960 each; and "Large Group Taps," costing $1,700 each. Company bears full cost of latter two types.

Cost: $10,000, with no individual project exceeding $2,000.

**Columbia Gulf Transmission Co., Houston, Texas, CP 156, filed December 2, 1960.**

Description: eight 30-in. lines (looping a total of 96.9 miles of the company's 841.1 mile long 30-in main line) and 28.9 miles of 12-in. supply lateral line connected to the applicant's east lateral between Louisiana and Kentucky.

Proposed loops:

12.7 miles between station 1 and 2 in Lincoln and Gerrard counties, Kentucky, near Stanford.

11.7 miles between stations 3 and 4 in Williamson and Davidson counties, near Nashville.

12.4 miles between stations 4 and 5 in Wayne County, Tennessee, near Waynesboro.

11.3 miles between stations 5 and 6 in Union County, Mississippi, near New Albany.

11.7 miles between stations 6 and 7 in Grenada and Yalobusha counties, Mississippi, near Grenada.

14.1 miles between stations 7 and 8 in Issaquena, Washington, and Sharkey counties, Mississippi, near Hollandale.

10.2 miles between stations 8 and 9 in Catahoula Parish, Louisiana, near Jena.

12.8 miles between stations 9 and 10 in Evangeline and Avoyelles parishes, Louisiana, near Bunkie.

Gathering facilities: 28.9 miles of 12-in. (¼ in. wall) lateral supply line in Terrebonne Parish, Louisiana, near Houma.

Cost: Loop lines, $11,685,800; gathering, $1,776,600.

**El Paso Natural Gas Co., El Paso, Texas, CP 61-180, filed December 30, 1960.**

Description: Construction to gather and dehydrate 10,000,000 cu ft per day from the Sawyer field, Lea County, New Mexico, then transport the dehydrated gas to Plant 29 of Sinclair Oil & Gas Company, the processed gas to be delivered into the applicant's existing 30-in. OD Permian-San Juan main line.

Facilities and costs: 14.2 of 6⅝ in. OD pipe, 0.156 w.t. and appurtenances

— $243,000 (material, $178,400; labor $64,000 — unit cost approximately $17,100 per mile); orifice-type meter station, $4,000; dehydrating plant, $22,000; 15 miles of field gathering pipeline in various lengths ranging in diameter from 4½ to 6⅝ in., $392,000.

**Natural Gas Pipeline Company of America, Chicago, Illinois, CP 61-185, filed January 6, 1961.**

Construction: 71.52 miles of 30-in. in Refugio, Victoria, and Wharton counties, Texas, looping portion of applicant's existing 26-in. pipe; 185.89 miles of 30-in. in Panola and Harrison counties, Texas — Clark, Hot Springs, Grant, Lawrence, Randolph, and Clay counties, Arkansas — Butler County, Missouri — and Washington, Clinton, Marion, and Livingstone counties, Illinois — looping portion of applicant's existing 30-in.; one 3000-bhp compressor engine in Victoria County, Texas, near Bloomington; and one 2800-bhp compressor engine in Wharton County, Texas, near Wharton.

Cost: 257.41 miles of 30-in. pipeline materials, as follows: 257.41 miles of pipe at $58,379 per mile, $15,027,400; external coating @ $1790 per mile, $460,860; internal coating @ $1584 per mile, $407,737; 75 cased highway and rail crossings @ $1396 ea., $104,700; 12 main line automatic valve settings @ $14,500 ea., $174,000; one intermediate crossover, $5500; 13 loop-end crossovers @ $8300 ea., $107,900; seven standard intake connections @ $25,400 ea., $177,800; five standard discharge connections @ $25,500 ea., $127,000; six standard block valve settings @ $12,800 ea., $76,800; 1370 river weights @ $0.75 ea., $102,750; miscellaneous materials @ $1663 per mile, $428,150; use tax, $249,298; blowdown, gas lost, purge, test, etc., $128,705. Rights-of-way and damages, $1,077,700. Installation, as follows: contract labor costs @ $23,047, $5,933,238; contract survey @ $300, $77,223; contract X-ray @ $225, $57,918; contract added lines on bridges, $65,000; company inspection @ $1150, $296,021; company tie-in work, 25 @ $6000, $150,000; total, $6,579,400. Total cost of main line loops: $25,235,700.

Cost: 3000-bhp addition materials, as follows: 3000-bhp compressor, $388,000; piping facilities, $31,000; building extension, $11,000; electrical facilities, $5000; other, $70,000; total, $505,000. Installation, as follows: contract construction, $72,000; contract X-ray, $1000; company supervision, $20,000; total, $93,000. 2800-bhp addition materials, as follows: 2800-bhp compressor, $358,000; building extension, $5000; piping materials, $38,000; other, $70,000; total, $471,000. Installation, as follows: contract construction, $77,000; contract X-ray, $1000; company supervision, $20,000; total, $98,000.

Materials: 30 in. by .34375 in. X-52 pipe; 30 in. by .4375 X-52; 30 in. by .375 in. X-52.

**Northern Natural Gas Co., Omaha, Nebraska, CP 61-186, filed January 6, 1961.**

Description: 7000-hp compressor station and 10-in. pipeline tie-over to connect existing 10-in. pipeline to a 16-in. pipeline from Winkler County, Texas, closely paralleling the Lea County, New Mexico, gathering line; also a dehydration plant next to the compressor station.

Cost: 10-in. side valve and tie-over line — company material, $5000; contract labor and material, $940; company labor, $40; mechanical equipment, $20; total, $6000. 7000-hp compressor station, $2,116,000. Dehydration plant, $83,000. Interest and overhead, $88,200. Total: $2,293,200.

**Ohio Fuel Gas Co., Columbus, Ohio, CP 61-170, filed December 21, 1960.**

Description: Main-line tap, 875 ft of 2⅜ in. OD pipe, and industrial sale measuring and regulating station, to deliver and sell gas to Nease Chemical Company, near Salem, Columbiana County, Ohio, for steam generation in new plant now under construction.

Cost: Tap and pipeline, $2,250; station, $6,540.

Transcontinental Gas Pipe Line Corporation has proposed additional facilities costing $30,000,000, which, when coupled with a pending $70,000,000 program, will bring new construction to $100,000,000 and increase the pipeline's daily allocated capacity to 1.4 billion cu ft.

Storage capacity would be increased to 457,000,000 cu ft per day, giving the line a maximum potential daily capacity of 1.9 billion cu ft per day.

The 1961 program includes approximately 500 miles of new pipeline construction in Texas, Louisiana, Mississippi, Alabama, Georgia, South Carolina, North Carolina, Virginia, Pennsylvania, and New Jersey. This will complete about half of the second looping of the company's main line.

Two new compressor stations and an increase in compression capacity of existing stations are included in the program.

**Southern California Edison Co., Los Angeles, California, CP 61-172, filed December 23, 1960.**

Description: To export natural gas, purchased in Texas, across the northern part of Mexico to a point on the U. S.-Mexican border at Mexicali, Mexico, from which point the gas will be imported into the U. S. again, for applicant's use in electric generating stations in southern California. SoCal Edison has entered into agreements with Humble Oil and Refining Company for purchase of the gas, and for purchase of additional gas from Petroleos Mexicanos. Involves construction of about 1600 miles of gas transmission line and appurtenant facilities by companies other than SoCal Edison (see **Tennessee California Gas Transmission Co.** and **California Gas Transmission Co.**)

Total cost of facilities: $165,000,000.

Construction details:

Texas System: 100 miles, 26 in. OD pipeline.

Mexican System: 1200 miles of 34 in. OD, and 50,000 compressor hp.

California System: 224 miles of 34 in. OD, 54 miles of 24 in. OD, 14 miles of 20 in. OD, 10,000 compressor hp.

**Tennessee California Gas Transmission Co., Houston, Texas, CP 61-173, filed December 23, 1960, related to CP 61-172.**

Description: Presidential permit to export gas and construct its share of the total pipeline system.

**Transwestern Pipeline Co., Houston, Texas, CP 61-168, filed December 21, 1960.**

Description: Additional facilities at gathering points in the Permian Basin of Texas and New Mexico and the Anadarko Basin in Texas and Oklahoma. Budget-type application.

Cost: Total not to exceed $3,000,000; with individual items limited to $500,000.

**United Gas Pipe Line Co., Shreveport, Louisiana, CP 61-176, filed December 23, 1960.**

Description: Tap, meter station, 0.012 miles of 4-in. pipeline. To supply United Gas Corporation in Van Zandt County, Texas, from point near Milepost 0 on applicant's 6-in. Van field to Mintola pipeline.

Cost: Pipeline: materials, $306; installation, $262; overhead, $72; contingency, $32; total, $672. Meter station: Materials, $4,721; installation, $1,238; overhead, $763; contingency, $336; total, $7,058.

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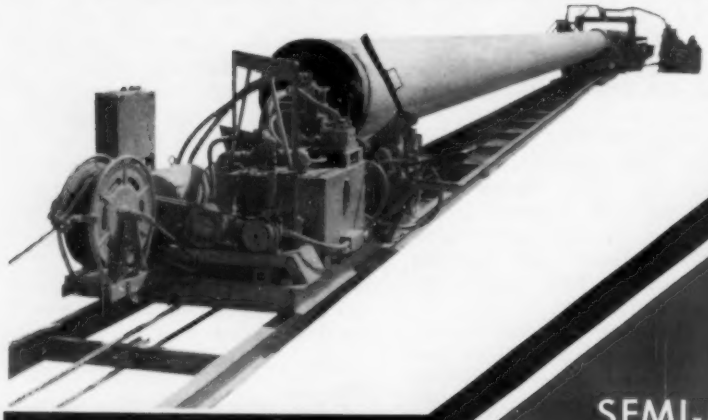

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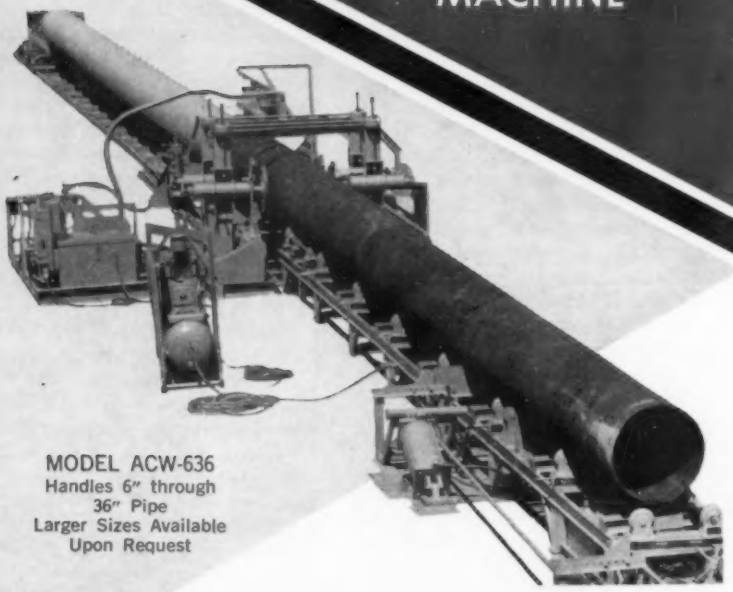

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| C* | 1½" x 60" | 2.0 | 25 | Ground Bed |
| D | 2" x 60" | 2.6 | 46 | Ground Bed |
| E | 3" x 60" | 4.0 | 115 | Salt Water |
| G | 2" x 9" | 0.4 | 5 | Ducts |
| J | 3" x 36" | 2.5 | 80 | Salt Water |
| M | 2" x 60" | 2.8 | 57 | Salt Water |

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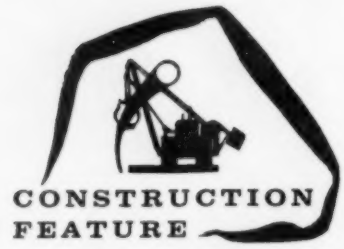
# PIPELINE PROJECTS




## Plans Link Between Future Lo-Vaca System And El Paso Natural

A newly-formed, wholly-owned subsidiary of El Paso Natural Gas Company is seeking permission to construct about 227 miles of 30-in. pipeline from a point in Live Oak County, Texas, where it would take gas from the previously announced Lo-Vaca Gas Gathering System and transport it to El Paso Natural's Sonora plant in Sutton County, Texas.

The Federal Power Commission has accepted El Paso Gas Supply Company's application for filing — and Coastal States Gas Producing Company, the firm planning to build the 330-mile Lo-Vaca system, has announced the signing of an agreement with El Paso Natural increasing gas delivery quantities and price escalation terms of an agreement concluded earlier this year between the two companies.

El Paso Gas Supply's application calls for construction totaling $29,649,000. This also includes a 7000-hp compressor station to be built at the origin of the 30-in. line, plus communication, metering, and appurtenant facilities.

The $10,500,000 Lo-Vaca system, planned by Coastal States to carry out its agreements with El Paso Natural, would extend from the Houston, Texas, area to Live Oak County, following a route close to several of Coastal States' existing gathering systems and producing fields. The Lo-Vaca system is expected to commence deliveries in 1961.

Under the new contract, Coastal States will sell to El Paso Natural an annual average of 130,000,000 cu ft daily, as compared with 100,000,000 cu ft agreed upon originally.

## Cal PUC Approves 93-Mile Gas Line From Nevada Border

The California Public Utilities Commission has approved a proposal of Southern Counties Gas Company and Southern California Gas Company to build a natural gas pipeline from the Nevada border into southern California.

Construction of the 34-in. line, which would supply up to 470,000,000 cu ft daily from sources in the Mid-Continent and Rocky Mountain areas, is expected to begin immediately, with completion expected in about a year.

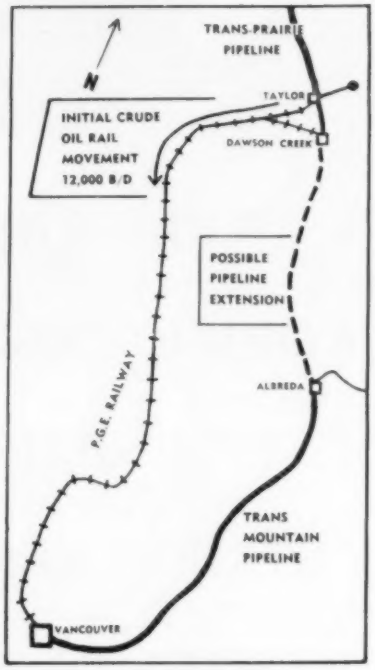
The Federal Power Commission has approved the interstate aspects of the line, other portions of which will be built by El Paso Natural Gas Company and Colorado Interstate Gas Company.

Southern Counties and Southern California Gas, Pacific Lighting Corporation subsidiaries, have budgeted $12,000,000 as their part of the cost of the $172,000,000 line.

The California portion of the line will link the Ivanpah Valley on the California-Nevada border to Newberry, 93 miles away.

El Paso will build 395 miles of line, and Colorado Interstate will construct an additional 359 miles of line in the Rocky Mountain and Mid-Continent areas.

## Trans-Prairie Studies Southern Extension




Trans-Prairie Pipelines, Ltd., having put into operation the southerly part of its new northeastern British Columbia crude oil gathering pipeline system, now is studying plans for a 160-mile extension of its system south to the Trans Mountain main line.

A probable entry point would be at Albreda, nearly half way between Edmonton and Vancouver. This would provide economical access to the Vancouver refineries for B. C. oil.

Several other companies, it is understood, are planning competing applications.

The connection to the Trans Mountain line could be laid in 1961 if plans proceed quickly.

# *Internationally . . .*

**In London,** a necessary Parliamentary bill is being sought for the construction of a 72-mile pipeline from Canvey Island, across London, to Denham. The intended formation of a new company, Trunk Pipelines Limited, also was announced. Three companies — Close Brothers, Marine & Remote Centre Oil Installations, and Collins Construction Company — are sponsoring the pipeline project. Route of the line would lie roughly through West Ham, Finsbury, St. Pancras, Kensington, Hammersmith, Wembley and Ealing, with spurs branching off at Dagenham, where Gulf Oil (Great Britain) has a depot, to Purfleet, where Esso and Shell-Mex and B.P. have depots, and another near Wormwood Scrubs leading to Fulham, where Petrofina has a depot, and then under the Thames to points south of the river. It is hoped later to extend the pipeline northward to the Mersey via Birmingham.

**Teikoku Oil Company,** having completed a 40-mile, 6-in. pipeline from its natural gas fields near Nagaoka to Niigata, about 168 miles north of Tokyo, also has begun to exploit natural gas in the Chiba Prefecture and hopes eventually to construct a pipeline to Tokyo.

**An Algerian crude oil pipeline** from the new Ohanet field to In Amenas, starting point of the existing Edjeleh-Tunisian pipeline, is reportedly under consideration by Compagnie d'Exploration Petroliere. It would be about 62 miles of 8 or 10-in.

**A new Saharan** 10-in. crude line, which will link El Agreb and El Gassi fields to the Hassi Messaoud-Bougie pipeline, is expected to be completed by May. The fields are about 75 miles south of Hassi Messaoud. The state-controlled company, Soc. Nationale des Petroles d'Aquitaine has a 51% interest, with the balance being held by three private French companies.

E. A. Olzewski, technician (left) and R. M. Howard, group engineer, both of Gulf Research, make a final adjustment on the new type batching separator "pig" before its initial test in a products pipe line.

# Batching "Pig" Reduces Interface 70%

GULF RESEARCH and Development Company scientists have developed and tested a mechanical batch separator that may ultimately save thousands of dollars for pipeline operators. Tests indicate the new device can reduce product commingling by approximately 70%.

The new separator operates on the principle of the conventional pipeline "pig". Like its grunting namesake, it looks as if it had spent too much time at the feed-trough. Its overall length measures 51-in. and it tips the scales at approximately 400 lb. The pig's shape, however, belies its utility.

Very simply, it is composed of a steel body bounded on one end by a rubber sphere and on the other by two standard pipeline rubber cups. (See illustration.) The large rubber sphere (24-in. in diam) has a wall thickness of approximately 3-in.

Prior to insertion in a line, the sphere is sized by filling with water so that its diameter is ¼-in. larger than the inside diameter of the line. This compresses it into a spheroid form with an area of approximately 3-in. wide around its diameter. As there is a differential of several pounds of pressure between the front and rear of the spheroid, it continually hugs the inside diameter of the pipeline. The two rubber cups attached to the rear of the device act as a piston for pushing the ball ahead.

Gulf Research and Development Company, a subsidiary of Gulf Oil Corporation, in cooperation with Laurel Pipe Line Company (owned jointly by Gulf, Sinclair Refining Company, and Texaco, Inc.), has made a series of field tests of the new batching separator pig.

In an initial test, the new batching separator pig was run in the main line of the Laurel Pipe Line Company system from its Booth terminal (near Philadelphia) to Mechanicsburg, Pennsylvania, terminal — a distance of 107 miles. The total travel time in this test was approximately 80 hr, or a little less than a mile and a half an hour.

At four locations along the system, the product was sampled continually prior to and following the pig's passage to determine whether mixing of the products was occurring across the pig. No appreciable mixing was observed. When it was removed for inspection at Mechanicsburg, there was little indication of abnormal wear on the unit.

A second test, run between the system's Eagle Point and Booth stations, a distance of approximately 23 miles, gave similar results. The interface between the two products was carefully controlled and measured to determine the effectiveness of the seal. Results indicated that interface had been reduced by more than two-thirds.

Laurel Pipe Line is using six of these pigs to conduct additional tests along its system. ★ ★ ★

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*Alberta Gas Trunk Line Company, Ltd.*—113 miles of 36-in. from Priddis, Alberta, to a point near Rocky Mountain House, and 64 miles of 16-in. from the main line near Waterton Park gas field to the Montana border near Carway. Alberta Consolidated is a joint venture of Mannix Company, Ltd., and Piggott Construction, Ltd., both of Calgary, Banister Construction Company, Ltd., Edmonton, and Marine Pipeline and Dredging, Ltd., Vancouver.

● **Banister Construction Co. Ltd., 625 Northern Hardware Bldg., Edmonton, Alberta, Canada.**

*Trans-Prairie Pipelines Ltd.*—160-mile crude oil system in northeastern British Columbia, as follows: 40 miles of 4-in., Taylor to Dawson Creek; 30 miles of 6-in., Boundary Lake to Taylor; 75 miles of 8-in., Taylor to Milligan Creek field; 11 miles of 4-in., Milligan Creek to West Beaton field; 2 miles of 8-in., Taylor station to tank car loading rack; and 2 miles of 4-in., Taylor station to McMahon refinery. Martin Balaski is superintendent on the 4-in. line from Dawson Creek, where field office is located, to Taylor, and Ron Smith is office manager. Bill Bartlett is superintendent on the 6-in. Boundary Lake-to-Taylor line; field office is in Fort St. John; and Don Parker is office manager.

● **Barney Bridges, N.E. of City, Ardmore, Oklahoma.**

*Rock Island Oil & Refining Co.* — 60-mile, 6 and 7-in. crude oil gathering system to serve Red Willow County, Nebraska, fields. A joint project with Gilmore Construction Company and Plains Construction Company.

● **Bechtel Corp., 220 Bush St., San Francisco 4, California.**

*Esso Standard (Libya) Inc.*—a 100-mile, 30-in. crude oil pipeline from the Zelten field in Libya, north to Marsa el Brega on the Gulf of Sirte.

● **Canadian-Parkhill Pipe Stringing Ltd., 164 Eglinton Ave., E., Toronto, Ontario, Canada.**

*Alberta Gas Trunk Line Co., Ltd.*—under subcontract from Dutton-Williams Bros., 20 miles of 22-in. and 62 miles of 30-in. from Windfall to Lovett River; under subcontract from Majestic Contractors Ltd., 63 miles of 30-in. and 38 miles of 22-in. from Lovett River to Rocky Mt. House, and 113 miles of 36-in. from west of Calgary to the British Columbia border; and under subcontract from Piggott Construction Ltd., 64 miles of 16-in. from the southend lateral to the Montana border. Field office: Calgary, Curtis Williams is general superintendent, Wes Strangh is office manager.

● **Cape Construction Co., Box 423, Cape Girardeau, Missouri.**

*Trunkline Gas Co.*—a 30-in. line from a point 8 miles north of Effingham, Illinois, to Neoga, Illinois, Cumberland County. Headquarters: Effingham. Superintendents: G. L. Mims and Ira Sugg.

*Mississippi River Transmission Corp.*—an 18-in. natural gas pipeline from near Johnsonville, Illinois, in Clay County, to St. Louis County (north of St. Louis, Missouri, where one field office is located), including dual 12-in. crossings of the Mississippi River. Other field offices: Carlyle and Salem, Illinois. Superintendents: R. C. Whitworth, G. L. Mims, and Trece Boyd.

● **Sam Carline, Inc., Box 138, Berwick, Louisiana.**

*Texas Gas Transmission Corp.* — a 12-in. crossing of the Atchafalaya River 3 miles north of Baldwin, Louisiana.

● **Collins Construction Co., Box 86, Port Lavaca, Texas.**

*Petroleos Mexicanos* — dual 12 and 24-in. natural gas pipeline river crossings between Pemex City and Mexico City, Mexico. Tom Broom is supervising.

● **Dutton-Williams Brothers, Ltd., North Canadian Oil Building, Calgary, Canada.**

*Alberta Gas Trunk Line Company. Ltd.*—62 miles of 30-in. from West Cynthia to West Whitecourt, Alberta, and 20 miles of 22-in. lateral from this main line to the Whitecourt field.

● **Eastern Pipeline Contractors, Inc., 820 Mercantile Bank Bldg., Dallas 1, Texas.**

*Southern Pacific Pipelines, Inc.*—approximately 3 miles of 6-in. and 64 miles of 8-in. products line from Atwater, California, to near Stockton. L. H. McIntyre is superintendent.

● **R. H. Fulton & Co., Box 1526, Lubbock, Texas.**

*Continental Pipe Line Co.*—550 miles of 2, 3, 4, 6, and 8-in. in Montana and Wyoming.

● **Gilmore Construction Co., Box 325, Hays, Kansas.**

*Rock Island Oil & Refining Co.* — 60-mile, 6 and 7-in. crude oil gathering system to serve Red Willow County, Nebraska, fields. A joint project with Barney Bridges and Plains Construction Company.

● **Grayco Constructors, Inc., Box 4147, Austin, Texas.**

*Trunkline Gas Co.*—approximately 20 miles of 30-in. from near Senatobia, Mississippi, southwest to near Ballontine, Mississippi. Emmett E. Wilkerson will supervise.

● **H & K Construction Co., S. San Patricio, Sinton, Texas.**

*Seadrift Pipeline Co.* — 80-mile dual 6-in. LPG line as joint venture with Roy Vickers Lease Service starting at Markham and ending at Baytown, Texas.

● **Hall Construction Co., 1105 N. Carlton, Liberal, Kansas.**

*Panhandle Eastern Pipe Line Co.*—a 330-mile, 4 through 12-in. gathering system in western Kansas. Supervising are Mike Bell and M. E. Banning.



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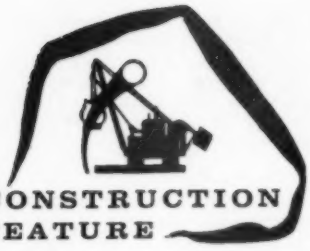


● **Harford Bros. Co., Box 191, Emporium, Pennsylvania.**

*New York State Natural Gas Co.*—an undetermined amount of storage field pipe near Duboise, Pennsylvania, under the supervision of Elmer Landis.

● **M. L. Hulcher Co., Inc., Box 168, Virden, Illinois.**

*Phillips Chemical Co.*—a 14,000-ft, 8-in. insulated ammonia line from Mississippi River unloading docks to the company's tank farm at East St. Louis, Illinois. Dale Smith is superintendent.

● **Latex Construction Co., Box 11668, Atlanta 5, Georgia.**

*Gulf Refining Co.*—terminal piping and mechanical work, Jacksonville, Florida, with J. M. Phipps supervising.

*Public Service Co. of North Carolina*—18 miles of 14-in. in North Carolina from Stem to Roxboro, under the supervision of O. P. Hiner.

● **Majestic Contractors Ltd., 49 Jackes Ave., Toronto 7, Ontario, Canada.**

*Alberta Gas Trunk Line Co., Ltd.*—113 miles of 36-in. from west of Calgary to the British Columbia border; and 63 miles of 30-in. and 38 miles of 22-in. from Lovett River to Rocky Mt. House to Cynthia, Alberta.

● **J. P. Neill and Company, Meadows Building, Dallas, Texas.**

*Pacific Gas Transmission Company*—468 miles of 36-in. from California-Oregon boundary to Rosalia, Washington, as joint venture with Western Pipeline, Inc., Austin, Texas.

● **Ohio Pipe Line Construction Co., Box 29, Newark, Ohio.**

*Buckeye Pipe Line Co.*—Relocating crude oil lines at Wooster and Roseville, Ohio, because of highway relocations. Headquarters: Newark, Ohio. Superintendent: Trent Ralston.

● **Panama, Inc., 1801 Tennessee Bldg., Houston 2, Texas.**

*Trunkline Gas Co.*—approximately 21 miles of 30-in. from 10 miles southeast of DeRidder, Louisiana, where office is located, to 10 miles northeast, under the supervision of C. J. Hendrickson; and about 21 miles of 30-in. from Mississippi, southeast of Memphis, Tennessee, to Colliersville, Tennessee, northeast of Memphis. A. J. McIntyre will supervise the latter job, with headquarters site at Colliersville.


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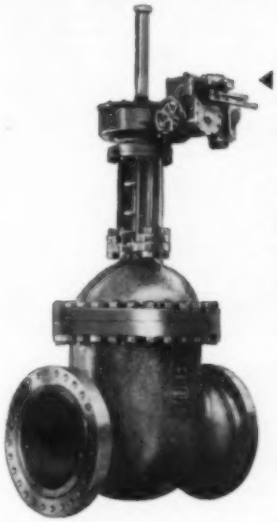

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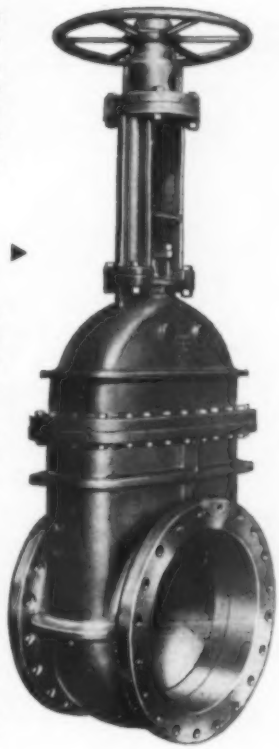

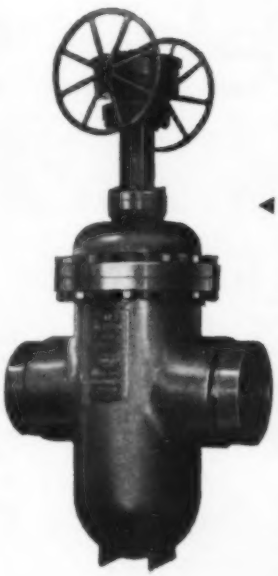

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**Williamsport 2, Pa.**

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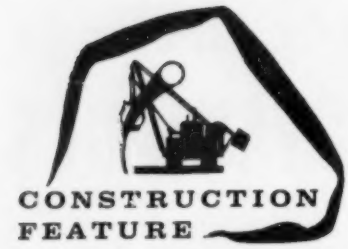


● **Panama-Williams Corp., 1418 Melrose Bldg., Houston, Texas.**

*Trunkline Gas Co.*—in Louisiana, 20 miles of 30-in. in the vicinity of Grove and 20 miles of 30-in. in the vicinity of Rayville, under the supervision of W. H. Shiflett and M. R. Sutton.

● **Plains Construction Co., Box 122, Kimball, Nebraska.**

*Rock Island Oil & Refining Co.*—60-mile, 6 and 7-in. crude oil gathering system to serve Red Willow County, Nebraska, fields. A joint project with Barney Bridges and Gilmore Construction Company.

● **H. C. Price Co., Price Tower, Bartlesville, Oklahoma.**

*Pacific Gas & Electric Co.*—291 miles of 36-in. to the California border from the San Francisco Bay area. Superintendent: R. L. Ezell. Office Manager: J. C. Eakin at Tulelake.

*Pacific Gas Transmission Company*—146 miles of 36-in. from Rosalia, Washington, to the Idaho-British Columbia border. Superintendent: G. A. Reutzel. Office manager: E. Dickson at Bonners Ferry, Idaho.

● **Price-Poole of Canada, Ltd., Box 969, Cranbrook, B. C., Canada.**

*Alberta Natural Gas Company* — 107 miles of 36-in. from Crowsnest Pass to the Idaho boundary at Kingsgate-Eastport. Joint venture of H. C. Price Company of Canada, Ltd., Calgary, and Poole Construction Company, Ltd., Edmonton.

● **River Construction Corp., Box 9127, Ft. Worth 7, Texas.**

*Peoples Gulf Coast Natural Gas Pipeline Co.*—75 miles of 30-in. in Arkansas from Galloway to Newport. T. M. Tatom is spreadman.

*Pacific Gas Transmission Co.*—36-in. single-line crossings of the Kootenai and Pend Oreille rivers near Bonners Ferry and Sandpoint, Idaho, respectively, sites of headquarters. H. H. Mehail is superintendent.

● **Alex Robertson Co., Box 757, Paramount, California.**

*William Lyles Co. (for U.S. Navy)* — 96-mile, 6-in. jet fuel line from Naval Air Station Lemoore to Estero Bay, California. Superintendent: Ken Pratt. Headquarters: Avenal, Shandon, Atascadero.

● **San Juan Basin Construction Co., Inc., Box 2116, Farmington, New Mexico.**

*Four Corners Pipe Line Co.*—27-mile crude gathering system from south of Farmington, New Mexico, to Farmington, with J. P. Workman and Robert Brown supervising.

● **Sharman, Allen, Gay & Taylor, Inc., Box 13152, Houston, Texas.**

*Seadrift Pipeline Co.*—112 miles of 6-in. products line from Seadrift to Markham, Texas. Headquarters: Port Lavaca. Superintendent: T. L. Beard.

● **Sheehan Pipe Line Construction Co., 514 National Bank of Tulsa Bldg., Tulsa, Oklahoma.**

*Transwestern Pipeline Co.*—a 600-mile gathering system of 4, 6, 8, and 10 in., in Oklahoma, Texas, and New Mexico.

● **Stanley-Bledsoe Corp., 612 Daniel Bldg., Tulsa 3, Oklahoma.**

*Pacific Gas Transmission Co.*—double-jointing and yard-treating 466 miles of 36-in. pipe in three schedules in Klamath, Jefferson, Umatilla, and Gilliam counties, Oregon, and Walla Walla and Whitman counties, Washington. Superintendent: W. D. Smith, Jr.

● **Troy Construction Co., 4840 Holmes Rd., Houston, Texas.**

*Dow Chemical Co.*—52-mile, 6-in. LPG line from Markham to Sheridan, Texas, with field office located in El Campo.


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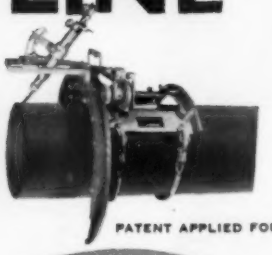

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● **Turriff-Burden, Ltd., Turriff Bldg., Great West Rd., Brentford, Middlesex, England.**

*Iraq Petroleum Co. Ltd.*—315 miles of 30 and 32-in. pipeline from Kirkuk to the Syrian border, connecting Rumaila and Fao. W. T. Barker manages the project office in London, England. Field construction superintendent is John H. Miller; assistant superintendent is Arnold Smith; and manager of the field office in Baiji, Iraq, is G. E. Suagee.

● **Vaughn and Taylor Construction Co., Inc., Box 3266, Odessa, Texas.**

*Monterey Oil Co.*—a 20-mile, 3 through 14-in. waterflood system in the vicinity of Fullerton field, Andrews County, Texas, with Jess Moore supervising.

*Kansas Gas Supply Corp.*—105 miles of 4 through 16-in. near Pratt, Kansas, under the supervision of D. D. Vaughn.

*Phillips Petroleum Co.*—20 miles of 4 through 10-in. near Spraberry, Texas, under the supervision of G. C. Laman.

● **Roy Vickers Lease Service, Box 648, Robstown, Texas.**

*Seadrift Pipeline Co.* — 80-mile dual 6-in. LPG line as joint venture with H & K Construction Company starting at Markham and ending at Baytown, Texas.

● **Western Pipeline, Inc., 311 East 11th Street, Austin, Texas.**

*Pacific Gas Transmission Company*—468 miles of 36-in. from California-Oregon boundary to Rosalia, Washington, as joint venture with J. P. Neill and Company, Inc., Dallas, Texas. J. C. Oliver is project manager. Johnnie Wells is superintendent on a 150-mile segment between Malin and Bend, Oregon; and Ervin Simpson is superintendent on 150 miles between Bend and north of Ione, Oregon.

*Trunkline Gas Co.*—21 miles of 30-in. in Kentucky from La Center to Columbus, and 21 miles of 30-in. in Illinois from New Dennison to Vienna. Headquarters: for the former, La Center, with D. C. Arnett as office manager; for the latter, Marion, Illinois, with Harry Murphy as office manager. Superintendents: for the former, J. B. Miller; for the latter, W. E. Wells.

● **Williams Bros. Co., National Bank of Tulsa Bldg., Tulsa, Oklahoma.**

*National Iranian Oil Co.*—a 516 mile, 8-in. petroleum products line in Iran from Rey, near Tehran, northeast to Meshed.

*Calnev Pipe Line Company*—240 miles of 8-in. products line from Las Vegas, Nevada, to Colton, California. Field office at Las Vegas, M. O. Thompson, superintendent.

*Bataafse Petroleum Maatschappij, N.V.*—a 157-mile, 20-in. pipeline in Indonesia. Field office: Balikpapan. Superintendent: J. Childress.

*Niederoesterreichische Gasvertriebs, AG (NIOGAS)*—47 miles of 8 through 10-in. in Austria. Headquarters: Herzogenberg. Superintendent: W. Tierney.

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# PIPELINE

D. M. Bailey

▸ **Southern Union Gas Company** has named as an executive vice president **Daniel M. Bailey,** who has been a vice president of Continental-Emsco Company since 1950. Bailey joined Continental in 1931 and served as assistant general counsel, general counsel, and assistant vice president before his elevation to the vice presidency.

▸ New transportation coordinator named by Gulf Oil Corporation is **W. C. Brodhead,** a veteran of 34 years of service.

▸ **O. C. Mudd,** consulting engineer of Alpine, Texas, and formerly chief corrosion engineer for Shell Pipe Line Corporation, has accepted an assignment with Pipe Line Technologists on a two-year project at Sydney, Australia.

▸ **George A. Seymour,** chief pipeline engineer of Mobil International Oil Company's producing department, has been transferred to Mobil Oil Company de Venezuela.

▸ **Transwestern Pipeline Company's** new purchasing agent is **Robert D. Hudson,** who, for the past six years, has been purchasing agent for Southwest Industries, Inc.

W. M. Jacobs

R. A. Hornby

▸ **Pacific Lighting Gas Supply Company's** board of directors has elected **W. M. Jacobs** president and **Robert A. Hornby** chairman of the board. **Robert W. Miller** will resign as board chairman but will remain board chairman of Pacific Lighting Corporation, parent of P.L.G.S. and of Southern California and Southern Counties Gas companies. Hornby also will continue as president of the parent company.

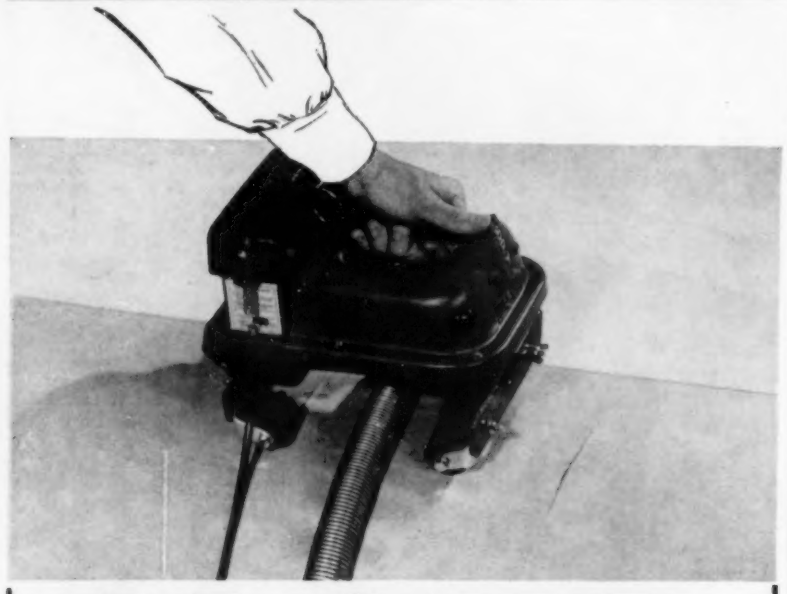
▸ **Sinclair Pipe Line Company** has promoted **T. F. Wingard** from assistant manager products movements department to assistant manager crude oil movements department, and promoted **G. M. Stout** from mid-continent chief division dispatcher to Wingard's former position. Named division chief dispatcher, products, is **C. J. Snyder,** formerly mid-continent assistant chief division dispatcher.

W. A. Strauss

▸ The promotion of **W. A. Strauss** to president and principal operating officer of Northern Natural Gas Company has been announced by **John F. Merriam** who remains chairman of the board of directors and chief executive officer of the company. Strauss also was elected a member of Northern's board and executive committee, as was **A. B. Dilworth.**

▸ **Arkansas Louisiana Gas Company subsidiaries** have two new vice presidents and a director. They are: **John E. Taylor,** elected vice president of Arkansas Industrial Pipeline Corporation; **Dave E. Sullenberger,** vice president of Arkansas Louisiana Chemical Corporation; and **Robert E. Welborn,** elected to the board of directors of Reynolds Gas Regulator Company, Inc.

▸ **L. Chase Ritts, Jr.,** has been appointed coordinator — crude oil production. purchasing, and transportation of Standard Oil Company (Indiana). Most recently vice president, division manager, and a director of Pan American Petroleum Corporation, Standard's oil-producing affiliate, Ritts, in his new position with Standard, will be responsible for coordination of activities with Pan American and also Service Pipe Line Company and Indiana Oil Purchasing Company, other Standard subsidiaries.

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# PERSONALS

Leon Payne

J. F. Robinson

W. J. Bowen

▸ **New president of** The Houston Corporation is **W. J. Bowen,** formerly senior vice president and director. Also, **Leon Payne,** who has been serving as a director for the company and its subsidiary companies, has been elected secretary and chief counsel. **J. French Robinson,** former chairman of Consolidated Natural Gas Company, has been elected chairman of the executive committee.

▸ **Texas Gas Transmission Corporation** has promoted **Robert N. Curry** from assistant superintendent of gas measurement to assistant superintendent of dispatching.

▸ **New market analyst** on sales and distribution for Transwestern Pipeline Company is **Harold J. Hewett, Jr.,** who was most recently with Sargo S.A. Oleoductos y Gasoductos on an Argentine project. He also has assisted in initial development of gas markets for Midwestern Gas Transmission Company and later was affiliated with Fish Service Corporation.

▸ **Five promotions** in Pacific Gas and Electric Company's gas department include: **Kenneth B. Anderson** from general superintendent of technical services to manager of pipeline operations, succeeding **Ralph S. Nabors** who becomes field supervisor of Pacific Gas Transmission Company, a PG&E affiliate; **Roscoe D. Smith** from general superintendent of transmission and distribution to manager, gas system design; **Edward F. Sibley** from supervising administrative engineer to manager of gas distribution, succeeded by **Robert W. Brooks,** former northern division superintendent of pipeline operations.

▸ **Election of Ned C. Turner,** vice president in charge of engineering and operations for Transwestern Pipeline Company, to the company's board of directors is one of several executive changes. **J. R. Butler,** one of the three founders and a director of the company who until recently has been secretary-treasurer, continues as chairman of the executive committee. **Raybourne Thompson** replaces Butler as secretary. **William A. Koros,** controller and assistant secretary, is now treasurer.

▸ **Columbia Gas System Service Corporation** has announced the retirement of **John E. Overbeck,** vice president, engineering and research.

▸ **Carl John Maki** is new manager of Texas Eastern Transmission Corporation's gas supply department and **John S. Adams** has been promoted to assistant manager. Maki, formerly assistant to the vice president of Dresser Industries, Inc., will be officed in Houston, Texas, and Adams will continue to be officed in Shreveport, Louisiana, where he is in charge of the gas supply section in gas division headquarters.

▸ **Aaron H. Griffin** succeeds **W. O. Davis** as manager of Texas Gas Transmission Corporation's Louisiana division. Davis has been transferred from Texas Gas' Lake Charles office to Memphis, Tennessee, where he assumes management of the pipeline department of the company's division office.

▸ **Ray J. Lynch** has been elected treasurer of both Michigan Wisconsin Pipe Line Company and American Louisiana Pipe Line Company.

▸ **A. R. Field** has been promoted from senior staff engineer for Continental Pipe Line Company to assistant district superintendent of an affiliate, Cherokee Pipe Line Company.

▸ **Eric S. Davis** and **R. F. Bruce Taylor** have been appointed vice presidents of Trans Mountain Oil Pipe Line Company and its subsidiaries. Davis joined Trans Mountain in 1953 as general superintendent and was appointed operations manager in 1954. Taylor joined the company as treasurer in 1952.

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## PIPELINE PARADE

**General Electric** will spend more than $1,000,000 in 1961 enlarging its communication products department headquarters plant in Lynchburg, Virginia, which houses two-way radio, microwave-multiplex and power line carrier current businesses as well as some military communications lines. A major portion of the 100,000-sq-ft structural expansion will be used to increase manufacturing productive capacity.

**Collins Radio Company has formed** a communication and data processing division to provide electronic data processing services to industry. It will integrate research, products, experience, and systems management capabilities of all Collins divisions and subsidiaries, which are also the new division's first customers as subscribers to a model system comprising the entire organization's communication and data processing facilities. On-line, real-time capability will be made available to industry customers when equipment development at the Dallas, Burbank, and Cedar Rapids laboratories is completed. It is planned to undertake outside service contracts with only a few selected subscribers within the next two years.

**Armco Steel Corporation plans to build** a continuous weld and electric-weld steel pipe mill at the Ambridge, Pennsylvania, plant of The National Supply Company, an Armco subsidiary. Expected to be completed within 18 months, the new mill can also be used to stretch-reduce seamless pipe to smaller sizes. It is part of a recently announced $95,000,000 project which also includes major facilities at Armco plants in Ashland, Kentucky, and Houston, Texas.

**Worthington Corporation** has enlarged its construction equipment division at Holyoke, Massachusetts, and named as its general manager, William H. Wheeler, formerly manager of sales, Holyoke division. The division will be responsible for sale of construction equipment products formerly handled by the resale sales department, marketing division, in Harrison, New Jersey.

**A newly equipped bronze foundry** with a melting capacity of 12,000 lb per day has been put into operation by **Darling Valve & Manufacturing Company,** Williamsport, Pennsylvania. The modernized foundry — with two Ajax "Multiductor" static frequency converters to operate four furnace shells — almost doubles the daily capacity of the old foundry.

**To serve its associated companies** in England, Canada, Holland, and Japan, as well as its U.S. market, **The Foxboro Company** has added a marketing division and appointed C. Schwarzler as vice president of marketing to head it. Named vice president and U.S. general sales manager is H. O. Ehrisman, while V. V. Tivy has been promoted to director of engineering.

**Manufacturing and marketing** for The Cooper-Bessemer Corporation's Type AM compressor line are now centered at the Houston plant of **C-B/Southern,** a division of the firm.

**Wright Industrial Products** has been named to represent **J. E. Lonergan Company** in the Houston and Dallas areas of Texas.

## equipment, services, sales

**Dresser Electronics is a new division of Dresser Industries, Inc.,** formed to provide a more unified identification in the rapidly growing electronics industry. It will include all the activity in the electronics field of two Dresser subsidiaries, Southwestern Industrial Electronics Company which will now be known as Dresser Electronics, SIE division, with George Peck continuing as its president, and Hermetic Seal Transformer division which will now become Dresser Electronics, HST division, with Peter L. Scott continuing as president.

### Appointments and Promotions

**Grove Valve and Regulator Co.** — J. D. McNeill, sales engineer for pipeline and production valves and pressure regulators in Canada, formerly with National Supply Company and Amerada Petroleum Corporation.

**Hydromatics, Inc.** — John A. Wiedmann, chief engineer, industrial division, formerly chief design engineer for Minneapolis-Honeywell missile equipment division and most recently section head of design engineering for Honeywell's valve division in Fort Washington, Pennsylvania.

**ITT Kellogg's** communications systems department — Hugh J. Tremblay, manager of marketing and sales, formerly coordinator of communications system programs.

**Insley Manufacturing Corp.** — L. K. (Ken) Ackmann, manager, eastern-central sales, formerly assistant sales manager.

**Kaiser Steel Corp.** — Thomas H. Wakeman, manager of plate, structural, and bar sales; Jack H. Webber, mid-continent district sales manager.

**Minneapolis-Honeywell Regulator Co.** — Charles W. Bowden, Jr., to the newly-created post of industrial sales manager, international division, with Arthur O. Dietrich succeeding him as advertising and sales promotion manager of Philadelphia-based divisions.

**Nordberg Manufacturing Co.** — George J. Wooldridge as sales engineer and Alden G. (Al) Wiedenhoefer as service engineer under Philip Wallach, district sales manager, Cleveland, Ohio.

**Pittsburgh Chemical Co.** — John E. (Jack) Himmelrich, pipeline products sales manager.

**Radio Corporation of America** — Walter C. Byrne, Jr., microwave marketing manager; Haddon S. Wilson, custom microwave project manager; and Norman E. Edwards, manager, microwave engineering.

**Raytheon Co.** — Curtis R. Hammond, commercial vice president, market development.

**Rockwell Manufacturing Co.** — Roy R. Bush, sales vice president, meter and valve division; and James H. Sells, district manager in the Houston area for the same division.

**Solar Aircraft Co.** — Paul A. Pitt, vice president, engineering; and Sumner Alpert, manager of a new division which includes Solar's aerospace, ground support, and industrial products.

**Walworth Co.** — Dr. Forest C. Monkman, vice president, research engineering.

**Worthington Corp.** — Frank J. Nunlist, vice president, operations.

**A new manufacturing outlet in Mexico** has been announced by **Frank Wheatley Pump & Valve Mfr.** Sales manager of Frank Wheatley Pump & Valve Mfr. de Mexico in Mexico City will be S. B. Schoelman, who has represented Pemex in New York City and Washington, D. C., for the past 17 years. Ted Kraft will direct manufacturing.

**Caterpillar Overseas S.A.** has been formed in Geneva, Switzerland, to sell and service Caterpillar products primarily outside the western hemisphere. In Australia and the United Kingdom, however, local Caterpillar companies will continue to handle such matters. V. V. Grant is president of the new company; R. H. Deffenbaugh, secretary-treasurer; J. R. Hawk, sales manager; and G. J. Preston, parts and service manager.

**Midwestern Pipe Line Products Company,** Tulsa, Oklahoma, recently guested about 50 engineers from pipeline construction and operating companies for a demonstration of the new Betzel portable pipe coating and wrapping machine which they distribute for the Betzel Company of Arlington, Texas.

**Formation of Williams Pressure Service Company, Ltd.,** for hydrostatic testing of pipelines has been announced by James Belding, vice president of the company. Home office is located in the Mobiloil Building, Calgary, Alberta, where Belding is manager. An additional office has been established in Edmonton where John Ench, vice president, is in charge. The new company is an affiliate of Williams Pressure Service Company of Shreveport, Louisiana.

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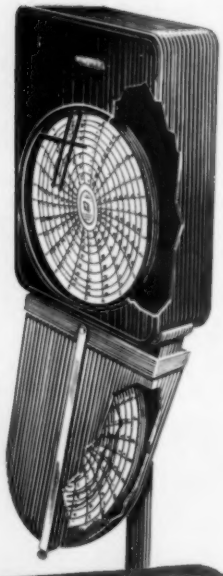

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## Diode Aids Communications

Tiny solid-state electronic devices — called "varactor" diodes because they act as variable capacitors when operting in electronic circuits — have been developed: to extend communications into higher frequency radio bands, multiplying amount of traffic that can be carried; and to make possible low-cost, high efficient, long-lived, and compact microwave signal receivers for a variety of applications. Seven types that operate within a 2000 to 20,000 mc frequency range have been announced. Made of high temperature gallium arsenide, they can pick up and amplify microwave signals transmitted at frequencies close to those of infra-red light. When operating in an electronic circuit, varactor diodes take a microwave signal and kick it to a higher energy level by phasing in a "pump" signal generated by another source within the circuit. The original signal is thus amplified and can then pass on through several additional stages of amplification until it is sufficiently strong to activate equipment such as a speaker or computer. *Radio Corporation of America.*

Circle number (81) on reply card.

## Has First Over-The-Ditch Application

A fast-drying primer called Bitumastic Jet-Set has had its first "over-the-ditch" pipeline application on a 33-mile section of a 20-in. gas pipeline over mountainous terrain. Under the conditions encountered on the job, the all-purpose primer dried in a matter of minutes, making it possible to run cleaning-priming and coating-wrapping virtually together. Bitumastic Jet-Set was applied cold and followed by a coating of Bitumastic No. 2 coal tar enamel. The covering was tar saturated #15 asbestos felt. The primer consists of synthetic resins and solvents blended to produce a liquid coating which may be applied cold by brushing or spraying. Coverage of the primer averaged 700 sq ft per gal. Compatible with all grades of coal tar enamel, it is said to be especially advantageous for applictions during wet or cold weather where drying is a problem. *Koppers Co., Inc.*

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## Newest In Potentiometry

ElectroniK 17 is a new industrial process potentiometer which incorporates an accurate, trouble-free electro-mechanical strain gage as the rebalancing element. In addition to the radically different rebalancing mechanism, the "Stranducer," the ElectroniK 17 features isolation of all critical components within an electrical shield, thus rejecting stray signals that cause recording errors and affect the dynamics of the instrument; one true reference junction compensation for all types of thermocouple actuation; and transistorized plug-in control units up to a maximum of eight set points for auxiliary or zone control. The new potentiometer, which can be mounted in a standard 19-in. relay rack, on a panel or bench, or made portable, consists of a single pen strip and circular chart recorders and circular scale indicator, each with or without control. *Brown Instruments Div., Minneapolis-Honeywell Regulator Co.*

Circle number (83) on reply card.

## Bucket Backfiller For Big-Inch Work

A one-man, foot-steering bucket backfiller — the Superior 150-B — which mounts on the International TD-15 crawler tractor — is designed for little and big-inch line work. With 12 speeds forward and reverse, from ⅛ to 7.1 mph, the rig has the mobility for fast clean-up of spoil banks and rapid location changes. "Hot clutch" time-outs are eliminated through absence of cone clutches. New, positive clutches in this backfiller's design run in oil. Backfiller control boards are hydraulically actuated. High boom clearance permits the in-haul cable of the 150-B to come in above the crawler's tracks, precluding possibility of the cable's dragging through mud. Counterweighting is dispensed wtih by mounting draw-works on the right-hand side. The operator can pivot the fully upholstered bucket seat to look ahead when traveling or face the ditch while working. On a recent test job on a 30-in. gas line, this bucket backfiller exceeded 16,000 linear ft in 12 hr in one pass, filling the trench two-thirds full. *International Harvester Co.*

Circle number (84) on reply card.

### Fast, Low-Cost Backfilling

A time and labor saver is the new "Pow-R-Ditch Filler" which deposits dirt back in the ditch in one pass with a front-mounted 24-in. power-driven auger 7½ ft long. Adjacent areas are left clear of debris and dirt. The backfiller is powered by a rear-mounted 36-hp Wisconsin engine.

Hydraulic power provides forward travel speed during backfilling. When in transport, the unit uses mechanical drive. Power steering is a standard feature. The 4-wheel-drive unit is jointed in the center for easy steering, better control, and greater ground grip from all four wheels. Operator's platform located above the auger allows unobstructed visibility both ahead and behind. *Vermeer Manufacturing Co.*

Circle number (85) on reply card.

### Low-Maintenance Welders

A 225-amp ac-dc engine driven welder — one of several new ones which are said to require minimum maintenance — can handle stick electrode welding, Heliwelding, and Aircomatic welding and can be utilized as an a-c power plant for applications other than welding. The power source supplies amperages from as low as 15 to 265 d-c, and 25 to 320 a-c. Of two d-c diesel welders recommended for pipeline service and heavy-duty construction, one is the "Yellow Jacket" in 300 and 400 amp rated sizes and powered by a 4-cylinder, 4-cycle injection-type diesel engine. It features steady welding current even when welding above the generator rating, quick response to arc starts, controlled current peaks, and high recovery voltage. The other — rated at 250 amp and utilizing a 4-cycle, 3-cylinder direct injection-type diesel engine — is available both as a d-c welder/a-c power plant or solely as a d-c welder. *Air Reduction Sales Co.*

Circle number (86) on reply card.

### High Solids Vinyl Coating

A new high build vinyl coating has been developed for application to all types of structural steel with either conventional or airless spray equipment. When Amercoat No. 99 is applied with the latter, only one cross sprayed coat is required to obtain a dry film thickness of more than 5 mils. Using conventional spray equipment, only two coats are required to produce a dry film thickness of 5 mils. The coating is said to barely sag even with a wet film thickness of 25 mils. The new coating is not a mastic, yet multiple coats are not required to achieve minimum protective thickness. Non-flammable, odorless, and non-toxic No. 99 will not harbor bacteria or fungi and dries to a hard, tough matte finish which adheres firmly and resists abrasion. *Amercoat Corp.*

Circle number (87) on reply card.


**MORE DITCH PER DOLLAR**

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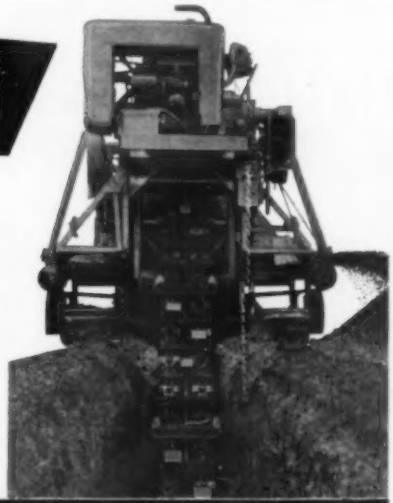
**POW-R-DITCHER**

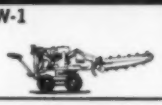
You just can't buy a lower priced BIG ditcher than Vermeer's 524T POW-R-DITCHER. Low original cost . . . low maintenance cost. Digs 8"-24" wide at speeds of 1' to 15' per minute. Ideal for contractors, municipalities, utility companies, pipe-line contractors and institutions.



**PICK THE POW-R-DITCHER TO FIT YOUR NEEDS**

4T

W-3

W-1 

3P

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☐ Also include information on new Vermeer hydraulic back filler.

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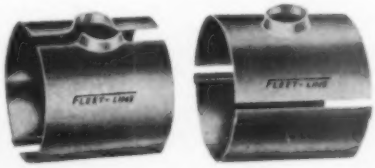

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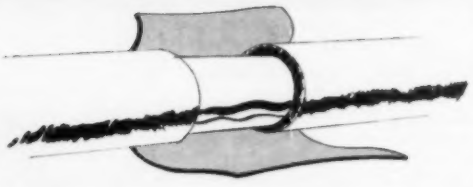

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This compact, but powerful Ditch Witch offers 4-wheel drive, 4-speed transmission, adjustable boom, many features! Digs trench up to 16" wide, 6' deep; digs even in frost or rocky conditions.

30 HP Model K-1 shown here

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### Measures Pipe-To-Soil

A Dacca potentiometer-voltmeter has been designed to give non-engineering personnel a simple, suitable meter for routine testing. For durability, a sealed, shock-resistant meter is used and the instrument is housed in an oak case with a removable lid. It operates on two standard flashlight batteries, which fit in the case. The whole instrument easily fits in one hand. Basis of operation is to determine voltages by opposing them with a known voltage through a galvanometer. A single 4½-in. meter serves as both galvanometer and voltmeter. Change from galvanometer to voltmeter is easily made by a spring return switch. *Agra Engineering Co.*

Circle number (88) on reply card.

### High Pressure Motor Valves

A new line of high pressure motor valves for working pressures up to 6000 psi features a hammer union type body which permits the inner valve assembly to be replaced in less than five minutes and topworks assembly that is interchangeable on all models and equipped with a pressed steel diaphragm case and nylon impregnated Buna-N diaphragm. A diaphragm travel indicator is provided, allowing field personnel to easily check valve position. The series offers a wide selection of body styles, orifice sizes, trim materials, and process connections. *Instruments, Inc.*

Circle number (89) on reply card.

### Special Computer Designed

A new type special purpose computer designed for installation at Tennessee Gas Pipeline Company's compressor station in Jamesville, New York, repeatedly calculates actual horsepower being delivered and adjusts pocket settings and number of engines running to allow each engine to deliver its maximum horsepower under any variations in operating conditions. It operates with telemetering equipment to allow a station in Onondaga County, New York, to completely control and monitor the Jamesville facility. This transistorized system is representative of "off-the-shelf" equipment designed and manufactured specifically for the solution of control and data handling problems. *International Controls Corp.*

Circle number (90) on reply card.

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**1960 Annual Index.**

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**Dallas 21, Texas**

### Protects Storage Vessels

A depressuring safety valve, designed to meet requirements for depressuring as set forth in API Tentative Standards RP-520, has been announced to protect high pressure storage vessels. This S & J Model 4280 disc-type valve is energized by pressure in the vessel being protected, product vapor pressure being applied to the upper portion of the disc through appropriate piping. It may be instrumented in any manner selected for remote opening and closing. Opening will always occur when pressure above the disc is vented by fusible plugs, control instruments, or manual control. Valve can be reclosed. The 4280 is designed to handle vapor over a wide range of pressures and temperatures and is economically adaptable to highly corrosive environments. *Shand and Jurs Co.*

Circle number (91) on reply card.

### Table Top Base Station

Introduced is a desk-top two-way radio base station which is 15 in. long, 18 in. wide, less than 9 in. high, and less than 40 lb in weight. The "Consolette" station provides 25-w power output when utilized with systems operating on high band (144-174 mc) frequencies and 30-w when used on low band (25-54 mc) frequencies. It utilizes a 300-w transmitter making it the highest powered unit in Motorola's standard line. Designed for operation in the 25-54 mc frequency band, the new base station can be used in conjunction with any Motorola two-way mobile or portable unit for greater punch and fringe area coverage. Available are a clock and built-in meter, any standard desk-stand and hang-up microphone or handset, and standard squelch and "private-line" dual squelch models. A shielded amplifier reduces cabinet radiation. *Motorola, Inc.*

Circle number (92) on reply card.

### For Small Diameter Line-Up

Now with a new C-R-C air line-up clamp, pipe as small as 12 and 14 in. can be lined up as accurately as pipe ranging from 16 to 36 in., cutting line-laying time, according to the manufacturer. The unit is 58 in. long, weighs 215 lb, and has a 1200-cu-in. air reserve tank permitting several line-ups without refilling. Featuring pneumatically-controlled heads which operate independently, the clamp affords quick, positive line-up even on two joints of different thicknesses and can handle pipe which has been shaped into maximum degree bend. Rollers roll pipe into a perfect round without friction or sliding on pipe surface, minimizing damage to pipe. Completely enclosed working parts assure low maintenance. *Crutcher-Rolfs-Cummings.*

Circle number (93) on reply card.

### Protects Parabolic Antennas

A new cone-shaped, molded fiberglass cover is said to be an inexpensive means of protecting parabolic antennas from the buffeting of severe winter weather. The Para-Dome costs from 35% to 50% less and is designed to withstand wind force of 50 lb per sq ft. Tests prove that signal attenuation between 2000 and 6200 mc is within 0.1 db. It is available for use with reflectors of 4 ft, 6 ft, 8 ft, and 10 ft sizes, with special sizes available upon request. *Tower Construction Co.*

Circle number (94) on reply card.


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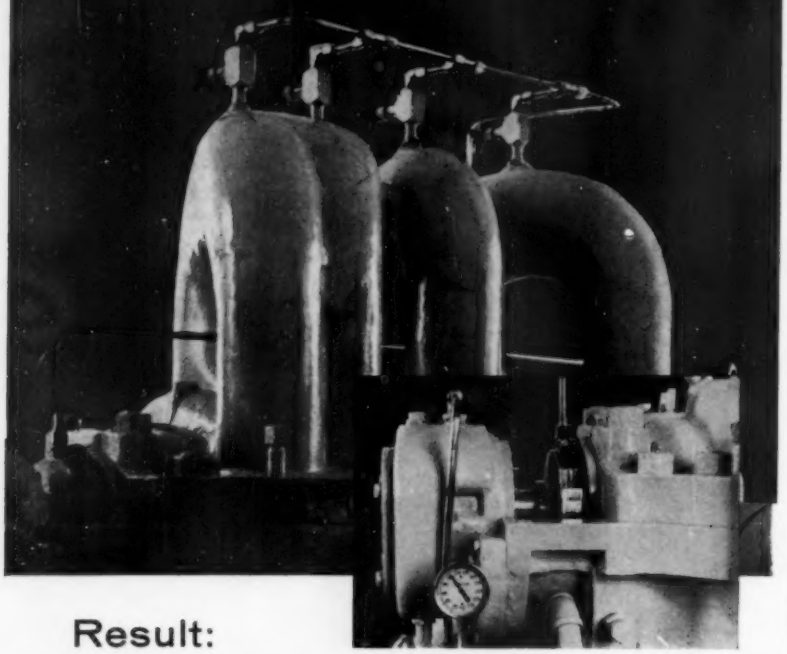
## *Atlantic Pipeline standardizes on Borg-Warner Mechanical Seals with exclusive "Pre-setting Ring"**

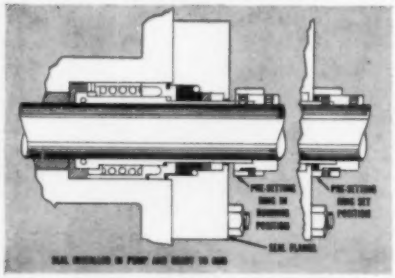


### Result:
### Up to 50% less maintenance

Since their first installation over four years ago, Atlantic Pipeline Company's Eastern Division has standardized on Borg-Warner Mechanical Seals on main line, booster and calibrating pumps. To date, experience with 26 pumps shows up to 50% less frequent maintenance; a marked decrease in product losses through leakage and evaporation; reduction of hazardous fumes; plus the economy of standard, interchangeable seals. Seals at Atlantic Pipeline's Product System operate under all conditions from inches of vacuum to 1300 psi, with *no pump down time due to seal failure!*

### Here's how it works:

Complete Seal unit slips onto shaft – bolts to the stuffingbox. Pre-setting ring is then locked in running position to assure perfect spring tension.



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# *It's New* Pipeline Literature

**Cold Coatings Pamphlets** . . . three of a scheduled series of 11 . . . now available. T-197-1 describes Bitumastic 11-S inhibitive primer recommended especially for application in severely contaminated atmospheres; T-197-2 features Bituplastic No. 33, a "modified coal tar emulsion coating" for multi-purpose protection; and T-197-3 discusses Bituplastic No. 44, a heavy-bodied emulsion material which combines coal tar protection with superior adhesive properties. *Koppers Co., Inc.*

Circle number (95) on reply card.

**How To Select Silencers** . . . a condensed design manual on methods for handling the problem of noise generated by gas flow devices used in industry. The bulletin discusses acoustic criteria to be met, describes acoustic and aerodynamic characteristics of various types of "Silentflow" gas handling silencers, and includes design charts to allow proper selection of the type of silencer and its optimum size. *Silence, Inc.*

Circle number (96) on reply card.

**Capacity Charts,** work ranges, and features of the Series 350 Bantam crane-excavators . . . plus description of front end attachments and features and specifications of six Bantam-built crane carriers . . . highlight a new, revised 12-page bulletin. *Schield Bantam Co.*

Circle number (97) on reply card.

**Servicing Instructions** for lubricated valves. An 8-page, 3-color bulletin describes by text and step-by-step illustrations the proper lubrication method for all types of Rockwell-Nordstrom lubricated plug valves, correct adjustment of valves, how to repack Hypreseal valves with plastic stem packing, etc.; and includes a chart of recommended lubricants and photos and description of lubricant dispensing equipment. *Rockwell Manufacturing Co.*

Circle number (98) on reply card.

**How To Remove Rust** . . . and prevent it . . . tested and proved procedures now detailed in a new service bulletin covering such common industrial problems as safe removal of rust from raw stock, prevention of hydrogen embrittlement during rust removal, simultaneous removal of rust and grease while conditioning surfaces for painting, rust prevention during storage, and anti-rust conditioning of steel in preparation for painting. *Oakite Products, Inc.*

Circle number (99) on reply card.

**Fiber Glass Components** . . . their innate strength, corrosion resistance, and dielectric properties . . . and the plant facilities which produce them . . . are described in a new bulletin. *Warminster Fiberglass Co.*

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For a welcome distinctive change in pipeline equipment, Mathey is proud to announce their newly designed Pipe Beveling Machine. It's extremely lightweight and requires only ½ the storage space. No. 1-SA machine can be operated on pipe segments as short as 9" and still cut 1" off pipe. In larger models weight is proportionately lighter.

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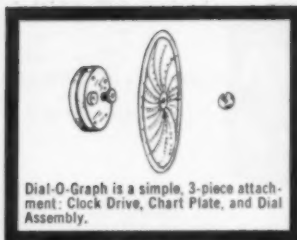
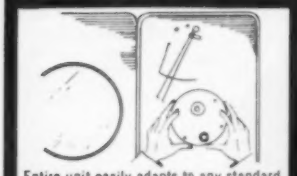
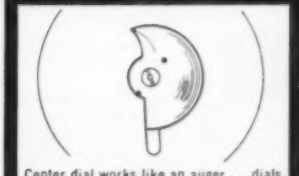


Dial-O-Graph is a simple, 3-piece attachment: Clock Drive, Chart Plate, and Dial Assembly.

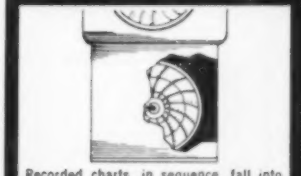


Entire unit easily adapts to any standard recorder . . . old or new . . . in the field or shop.

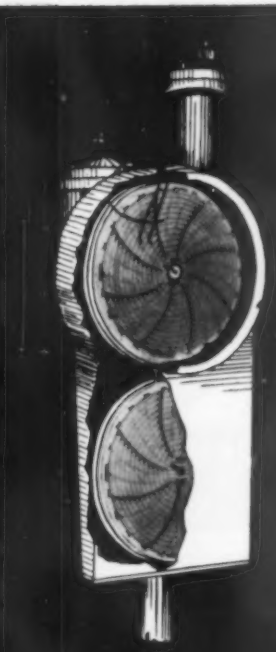
Current chart is always in full view. Dial-O-Graph does not affect recording, or appearance of chart.



Center dial works like an auger . . . dials off completed chart in 1/10-sec. New recording begins instantly.



Recorded charts, in sequence, fall into magazine under instrument, can be removed at any time.



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**PIPELINE** station recorders can operate automatically for days or weeks . . . completely unattended . . . with accuracy, continuity, and dependability assured. Any recording cycle is possible—without incurring extra expense for additional routes or personnel to change charts manually. An entire system or plant can be synchronized to change charts at exactly the same time—an advantage that is virtually impossible with personal attendance. Personnel problems are reduced . . . data is more accurate and reliable . . . accounting records are better.

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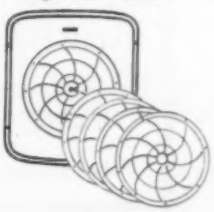

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**How Honeywell Charts and Inks Are Made** . . . the complete story in a new catalog. Partial lists of the most commonly used "ElectroniK" strip and circular charts, and pneumatic and electric "Tel-O-Set" charts, also are included. *Minneapolis-Honeywell Regulator Co.*

Circle number (101) on reply card.

**New Table Model** base station two-way radio which serves as a control center to permit dispatcher or office secretary to talk to mobile radios in vehicles, shoulder-strap portables, or shirt-pocket message receivers . . . now described in bulletin ECR-816. *General Electric Co.*

Circle number (102) on reply card.

**High Pressure** packaged compressor systems . . . a portable, air-cooled unit suitable for field use and a stationary, water-cooled machine . . . are featured in a new bulletin which tells how their balanced/opposed design eliminates vibration, describes crosshead type construction, and points out other features. *Clark Bros. Co., Div. of Dresser Industries, Inc.*

Circle number (103) on reply card.

**Utility Applications** of two new compact crawler tractors are pictorially described in a new catalog. Illustrated information covers engineering, design, and construction features. *Allis-Chalmers Manufacturing Co.*

Circle number (104) on reply card.

**Propeller Type Flowmeter** that transduces gas velocity to a millivolt signal, the frequency of which is proportional to flow rate, is described in a new bulletin. Full details on material of construction, mounting, performance, output, and repeatability are given. *Fischer & Porter Co.*

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**Plastic Valve Circular** features a comprehensive, 4-page *application table* that rates PVC's effectiveness on over 300 fluids and illustrated descriptions and dimensions of all Walworth PVC valves (Y-globe, check, bleeder, and diaphragm), strainers, unions, fittings, and expansion joints. *Walworth Co.*

Circle number (106) on reply card.

**Flow Rate Measurement Meters** designed to operate at pressures up to 1500 psig are the subject of a new bulletin. *Brooks Instrument Co., Inc.*

Circle number (107) on reply card.

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PHOTO ELECTRIC PANEL
Automatically turns Tower Lights ON and OFF in accordance with FCC regulations
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**TOWER LIGHTING CONTROL UNIT**
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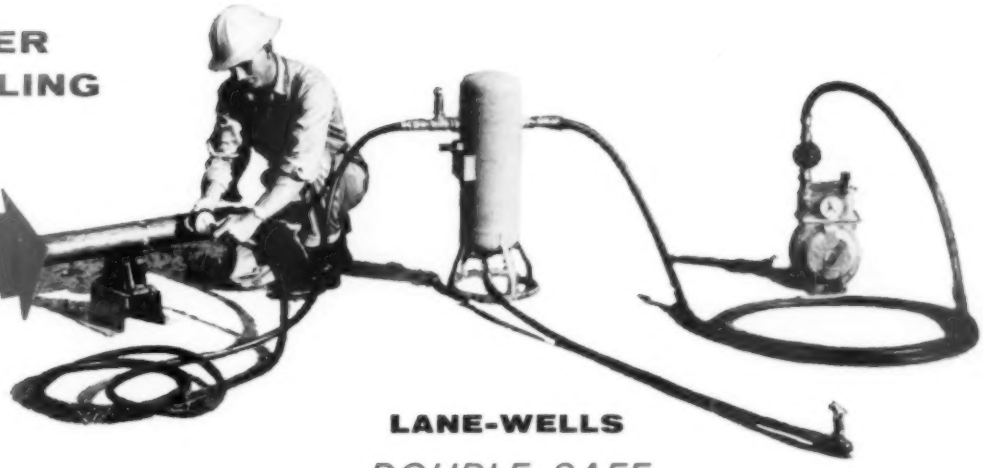

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- Complete film record of hydraulic, formation and hydrostatic pressures.
- All valves operated electrically from surface.
- Two equalizer valves for positive release.
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The Lane-Wells wire line Formation Tester obtains both formation fluid samples and valuable pressure data with a new level of safety never before possible.

This tool may be used at any time during drilling. It is positioned by correlation with an SP curve. After the sealing pad and back-up shoe are set and held by hydraulic pressure, access of the formation is obtained by means of a Koneshot charge.

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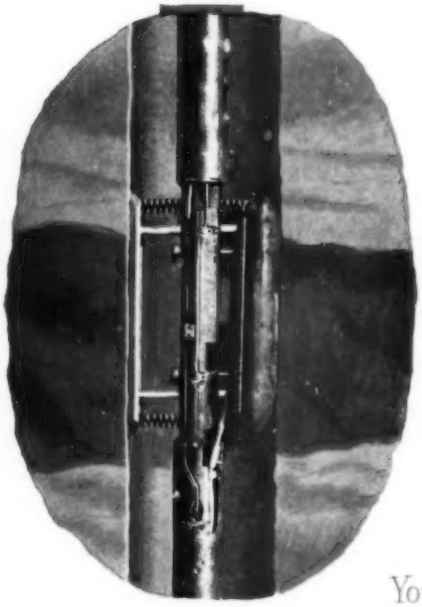
A complete film record of hydraulic pressure in the sealed section, formation flowing and shut-in pressures and hydrostatic pressure of the borehole fluid provide additional valuable information.



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## -the jet bit with built-in speed... and records prove it!

The Hughes OSC-3AJ is fast . . . it's rugged, and it's versatile. Some of the records set with the OSC-3AJ are spectacular. As an example, a Gulf Coast well was recently drilled to 10,000 feet in 3 days and 7 hours: actual rotating time — 46 hours. Only five bits were used; one 12¼" and four 9⅞".

The previous record for a 10,000-foot well in this area was made with Hughes OSC-3J's. We don't pretend that the penetration rate or footage drilled in the record well is par for the OSC-3AJ. But one thing this record does prove is the outstanding performance built into the bit.

The Hughes OSC-3AJ was originally designed for "top hole" digging. But its exceptional performance in low-strength, high-drillability formations and its availability in a wider range of sizes is extending its use to greater depths and in an increasing number of areas of the world.

*Ask the Hughes man in your area about the performance you can expect with the OSC-3AJ*

**HUGHES TOOL COMPANY** ORIGINATOR

AND WORLD'S LEADING DEVELOPER OF CONE-TYPE ROCK BITS